

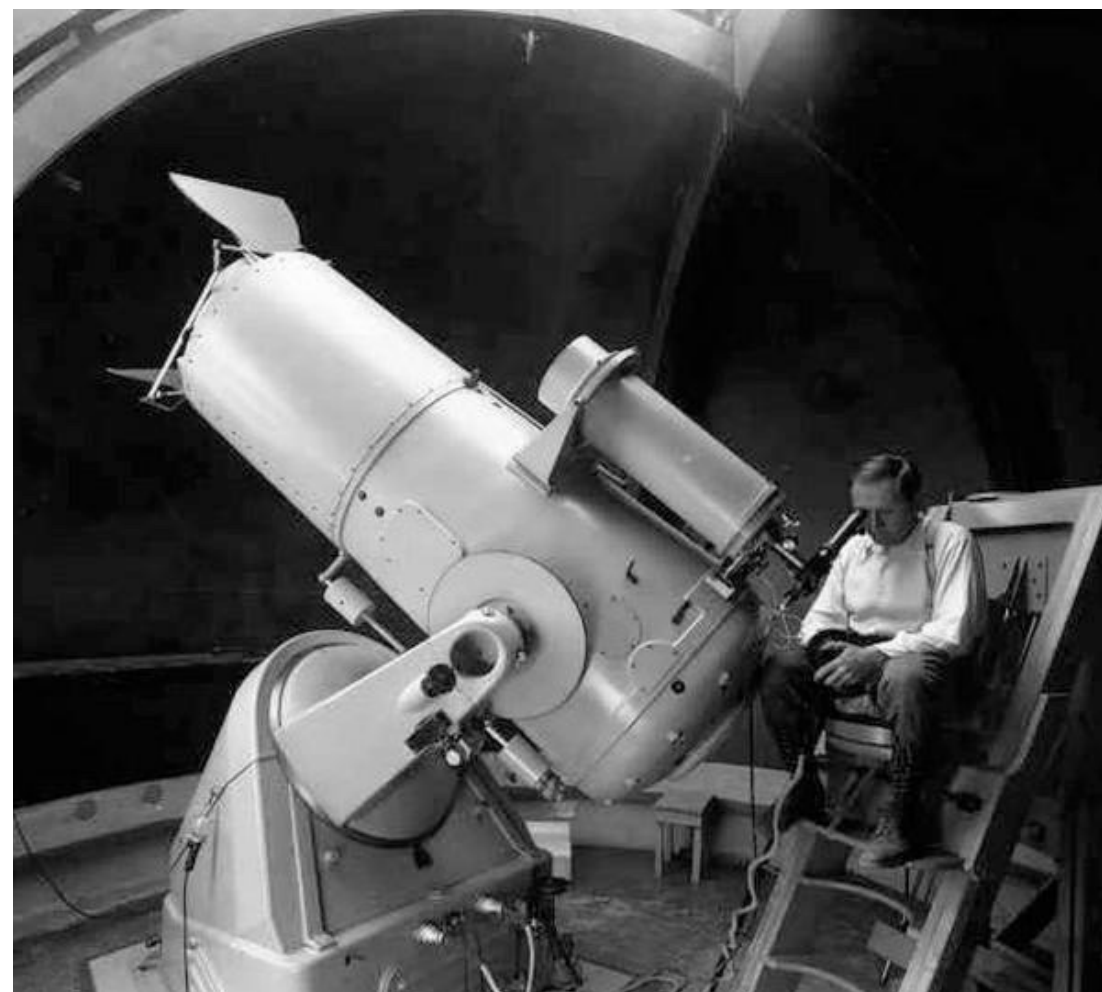


ZWICKY TRANSIENT FACILITY

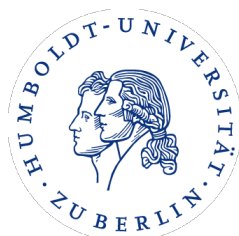
Eric Bellm

ZTF Project Scientist

ptf.caltech.edu/ztf



Caltech



ZTF will conduct LSST precursor science.

LSST is designed to achieve goals set by four main science themes:

1. Probing Dark Energy and Dark Matter
2. Taking an Inventory of the Solar System
3. Exploring the Transient Optical Sky
4. Mapping the Milky Way

Ivezic+ 11

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Ivezic+ 11

ZTF is a time-domain survey at Palomar Observatory.



Moderate aperture survey matched to followup resources.

The PTF survey family has three phases.

PTF *yesterday*

The Palomar Transient Factory
(2009-2012)

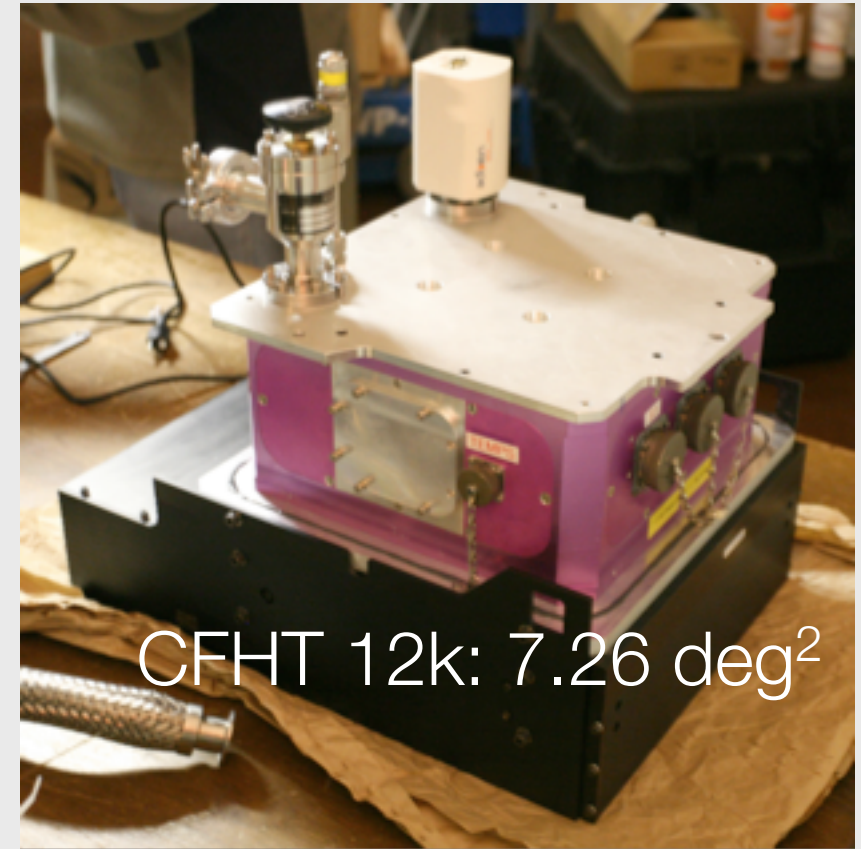
General synoptic transient survey

iPTF *today*

Intermediate Palomar Transient Factory
(2013-2017)

Focused mini-surveys

137+ papers, 4960+ citations



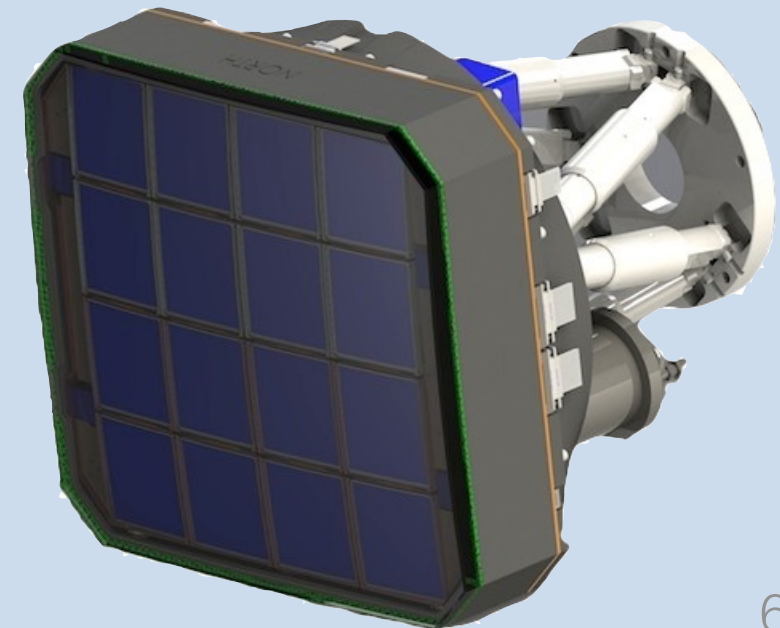
CFHT 12k: 7.26 deg²

ZTF *tomorrow*

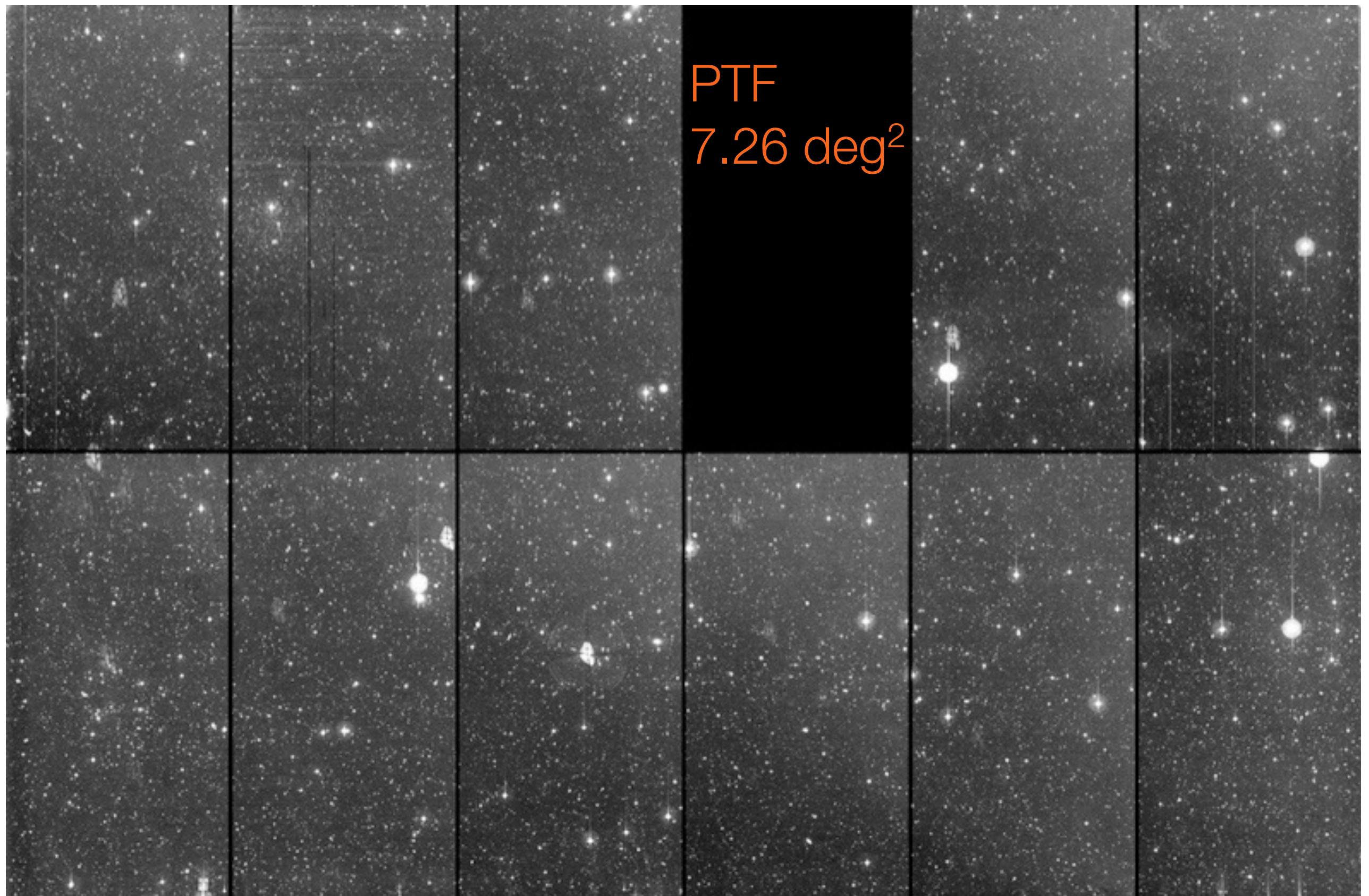
The Zwicky Transient Facility
(2017-2020)

High-cadence, wide-area survey

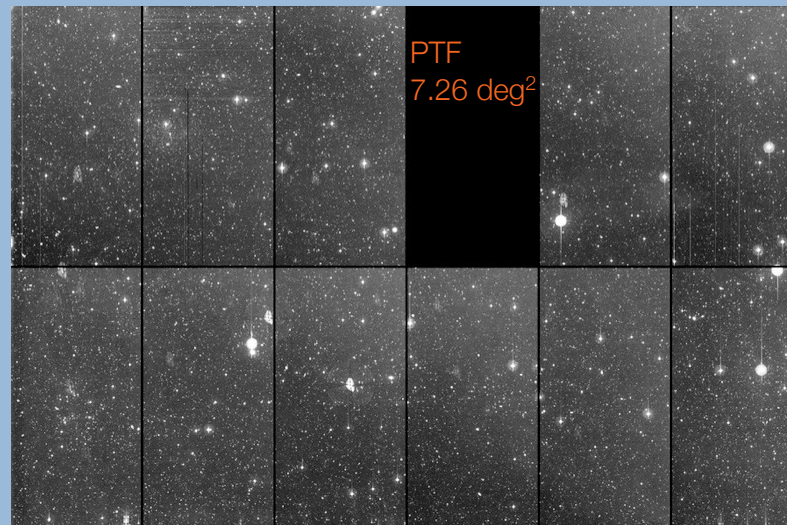
new 47 deg²
camera



A new camera will fill the P48 focal plane.

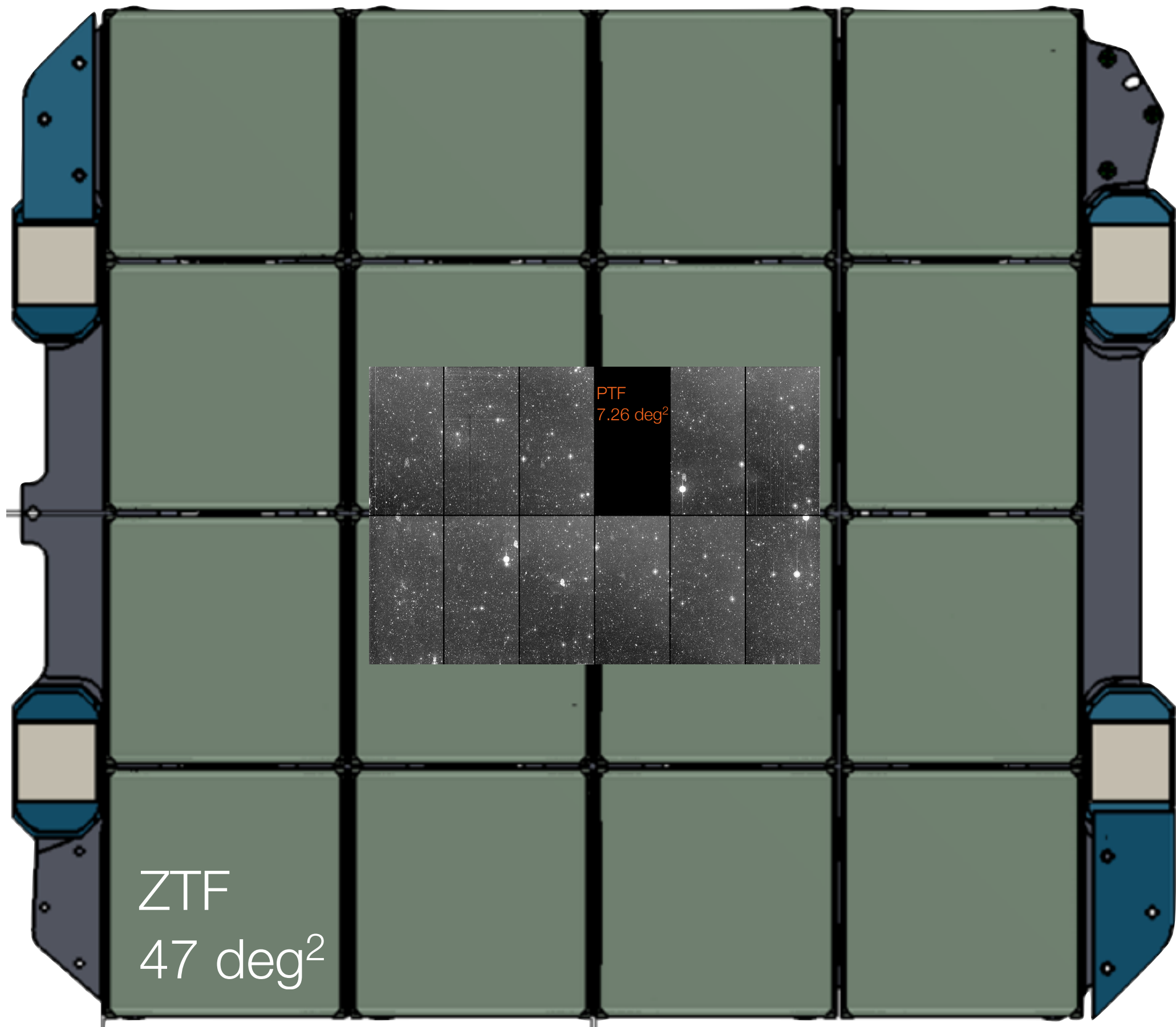


A new camera will fill the P48 focal plane.

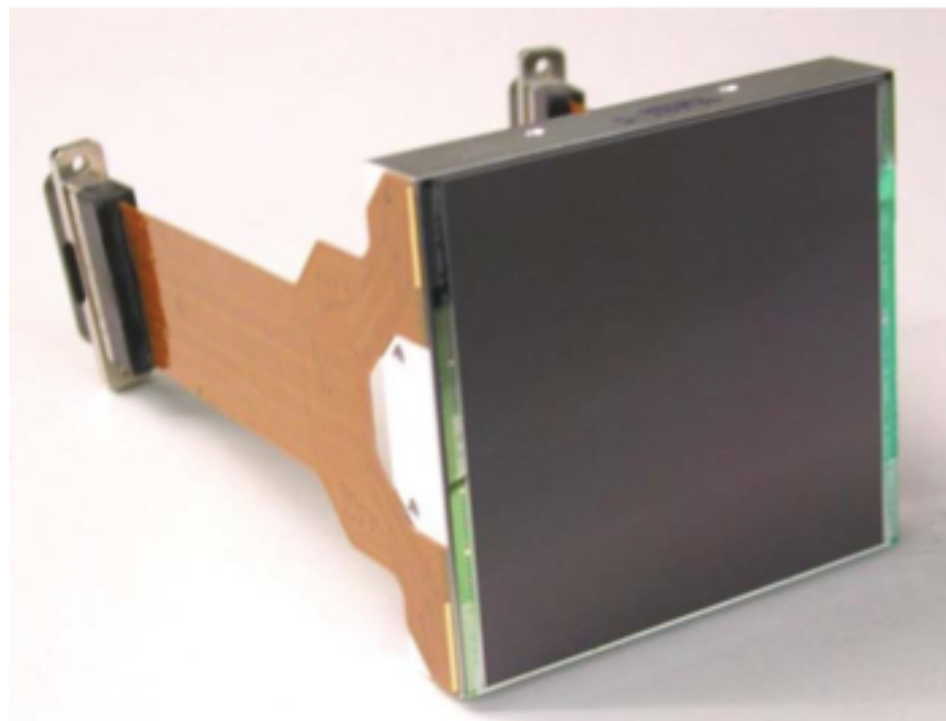


POSS plates
43.6 deg²

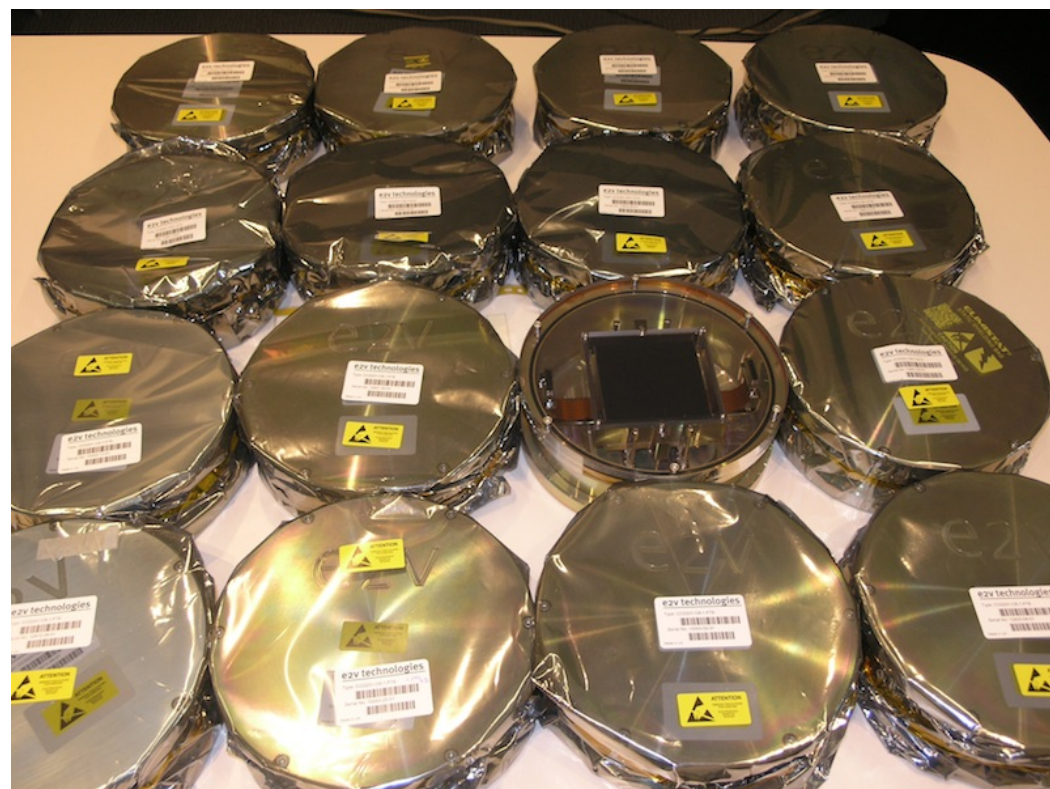
A new camera will fill the P48 focal plane.



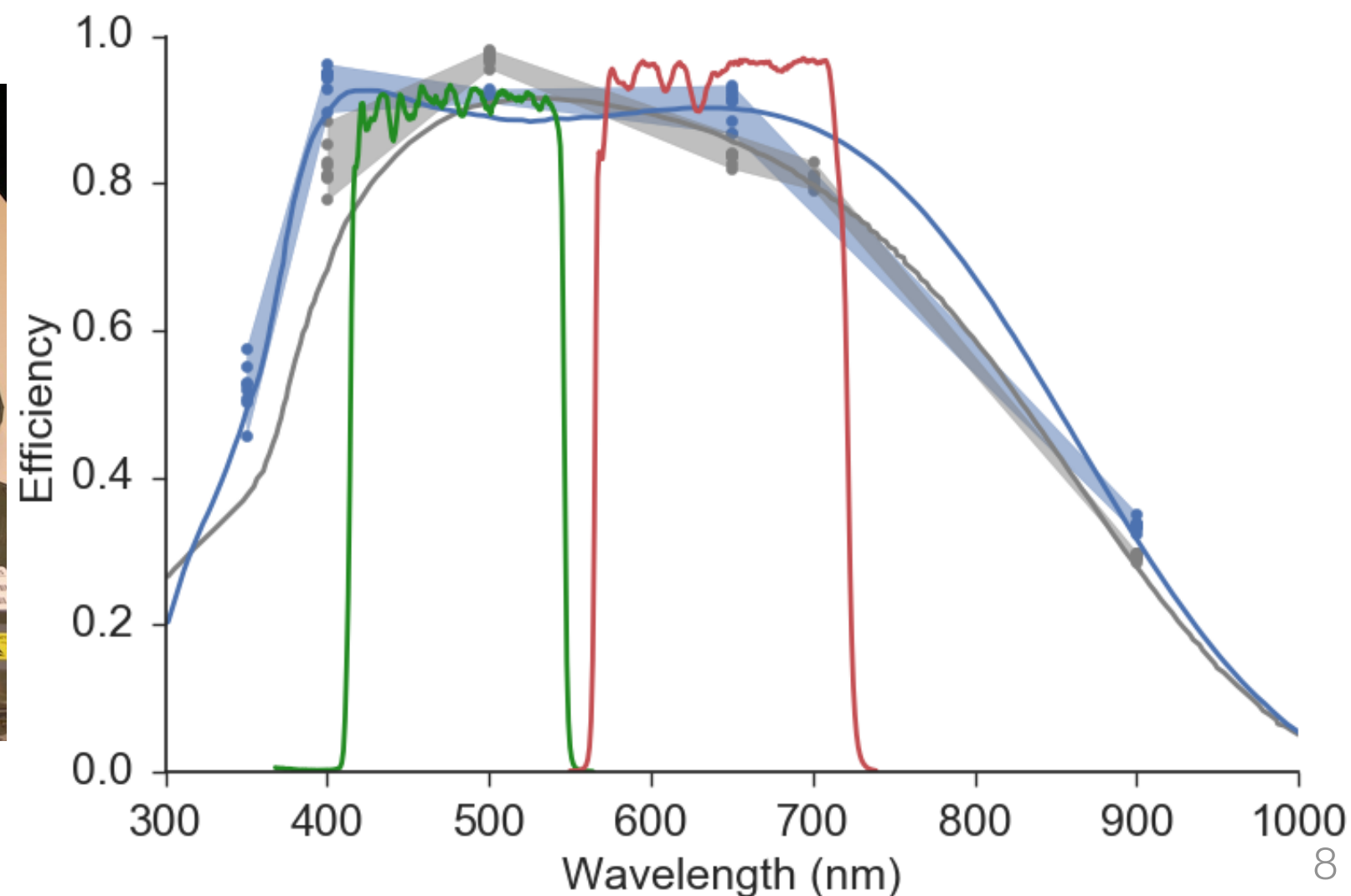
Affordable wafer-scale CCDs make ZTF possible.



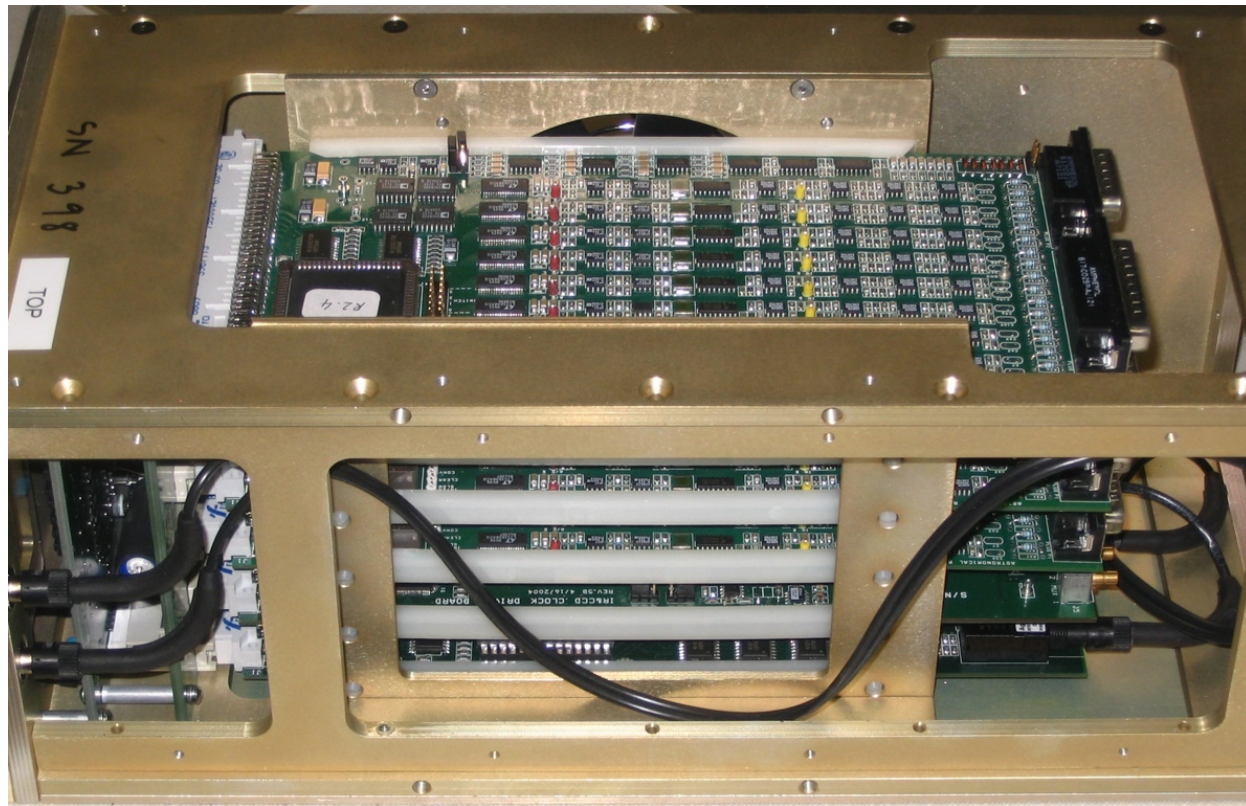
e2v	
dimension	9.2 x 9.2 cm
pixels	6.1k x 6.1k
pixel size	15 micron
pixel scale	1"/pixel
outputs	4



all 16 CCDs delivered!

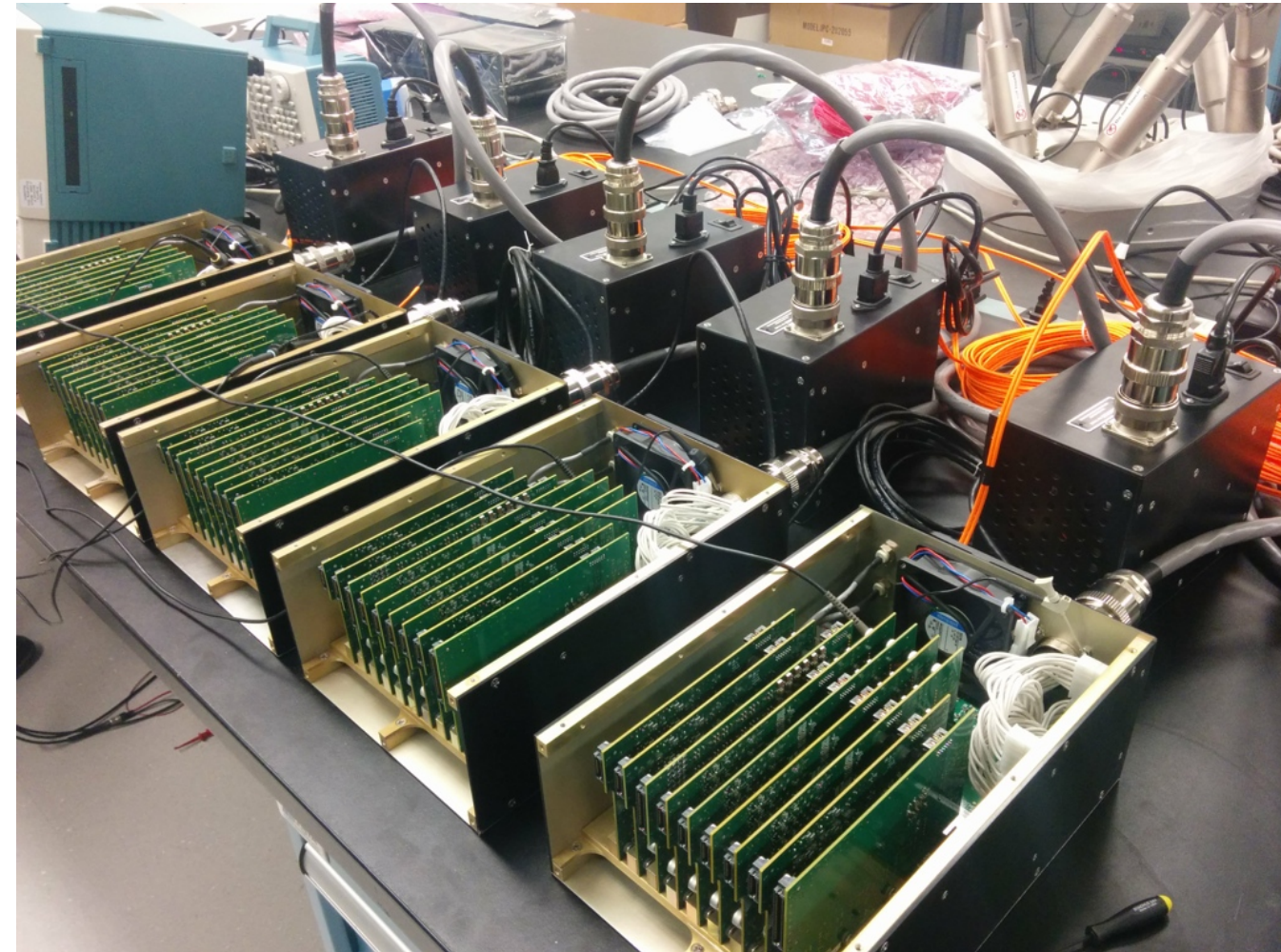


Moore's Law reduces overhead.



PTF

2000-era Leach Gen-II controller
36 second readout of 96 Mpx

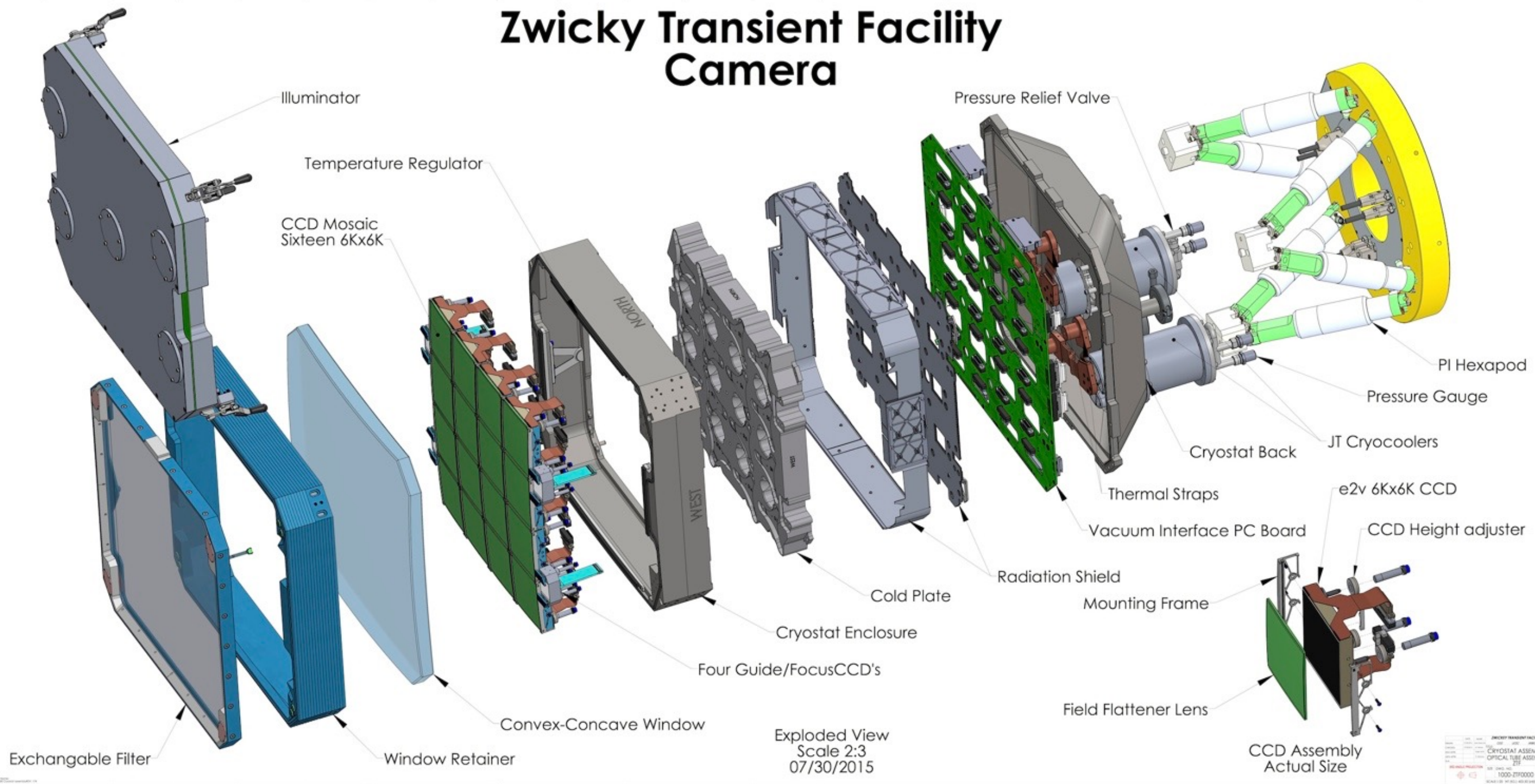


ZTF

modern STA Archon controller
10 second readout of 576 Mpx

bench testing in progress

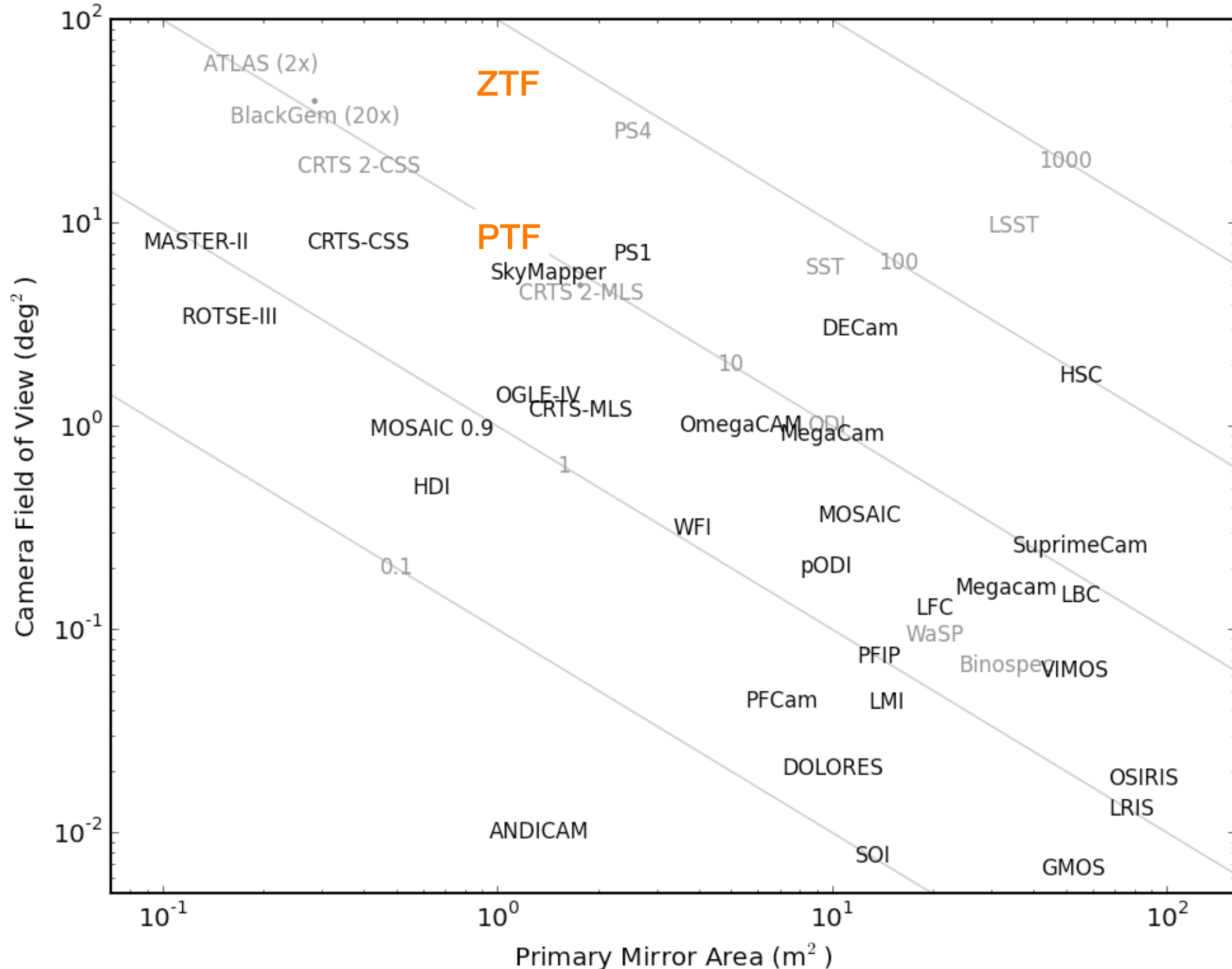
Fabrication has begun on the ZTF cryostat.



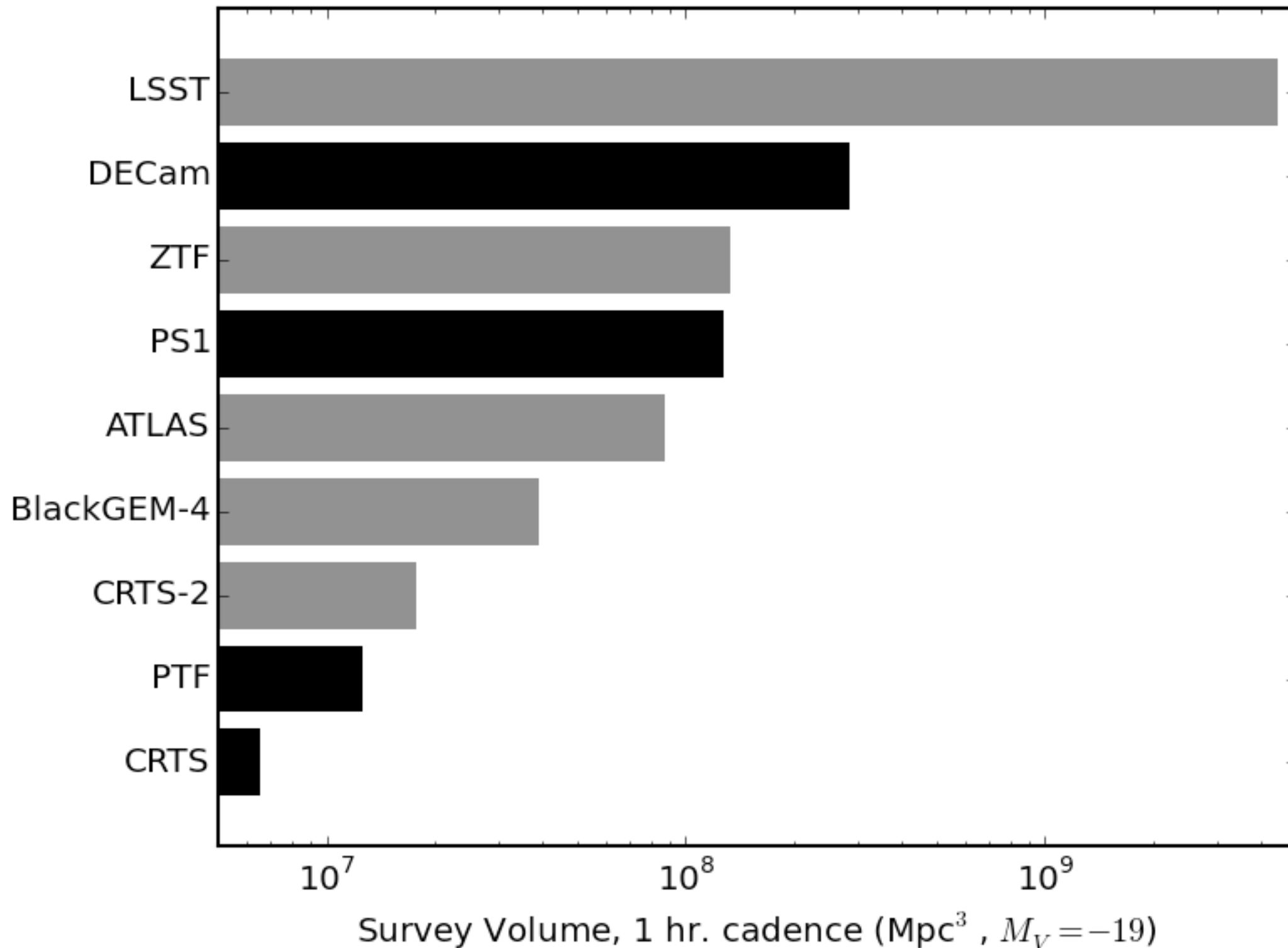
CCD installation in May 2016

conceptual design: LBNL
detailed design: Caltech

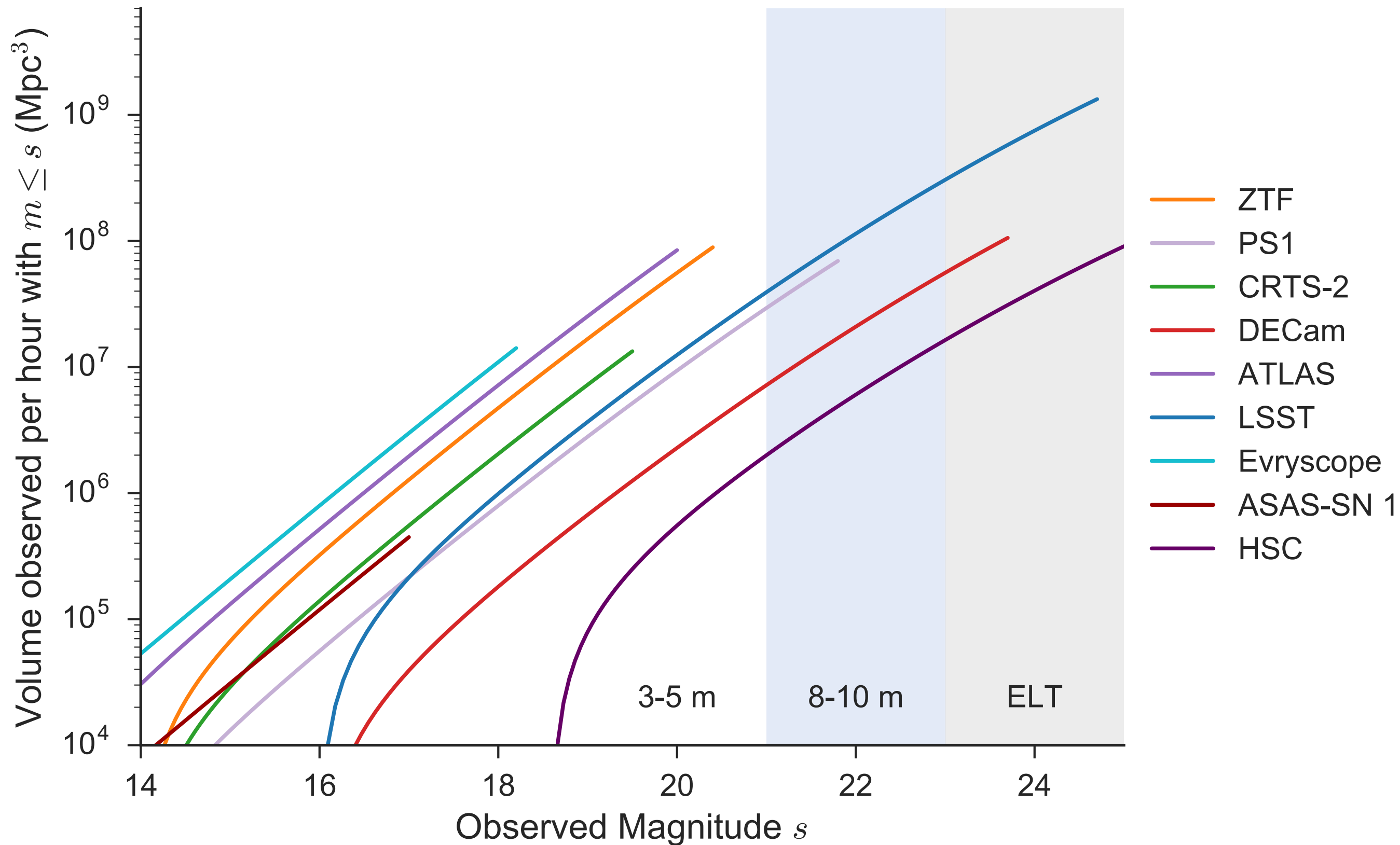
ZTF will have the largest field of any meter-class camera.



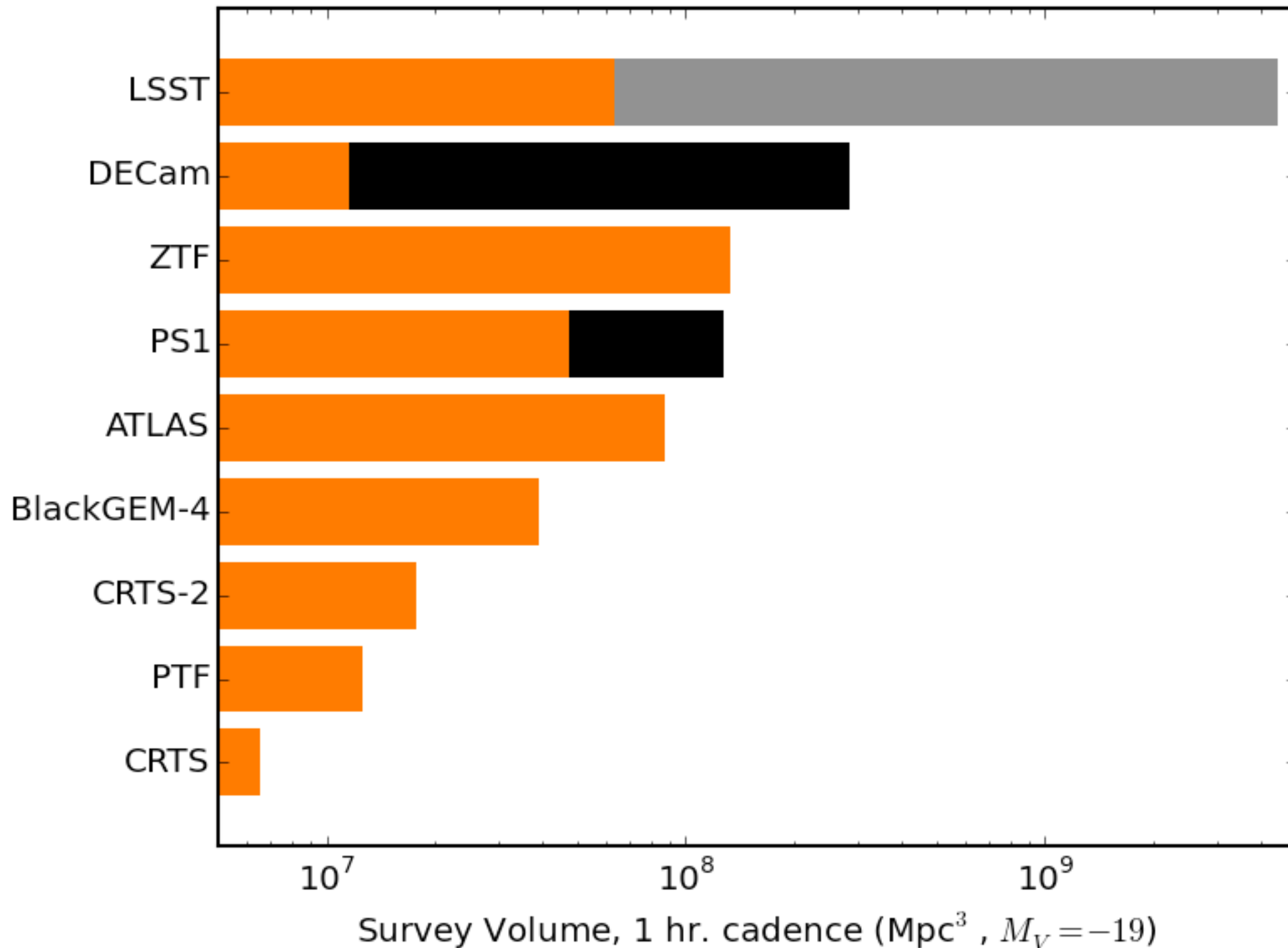
New surveys are exploring ever-larger survey volumes.



Fainter transients are harder to classify.



ZTF will have world-leading speed in finding spectroscopically-accessible transients.



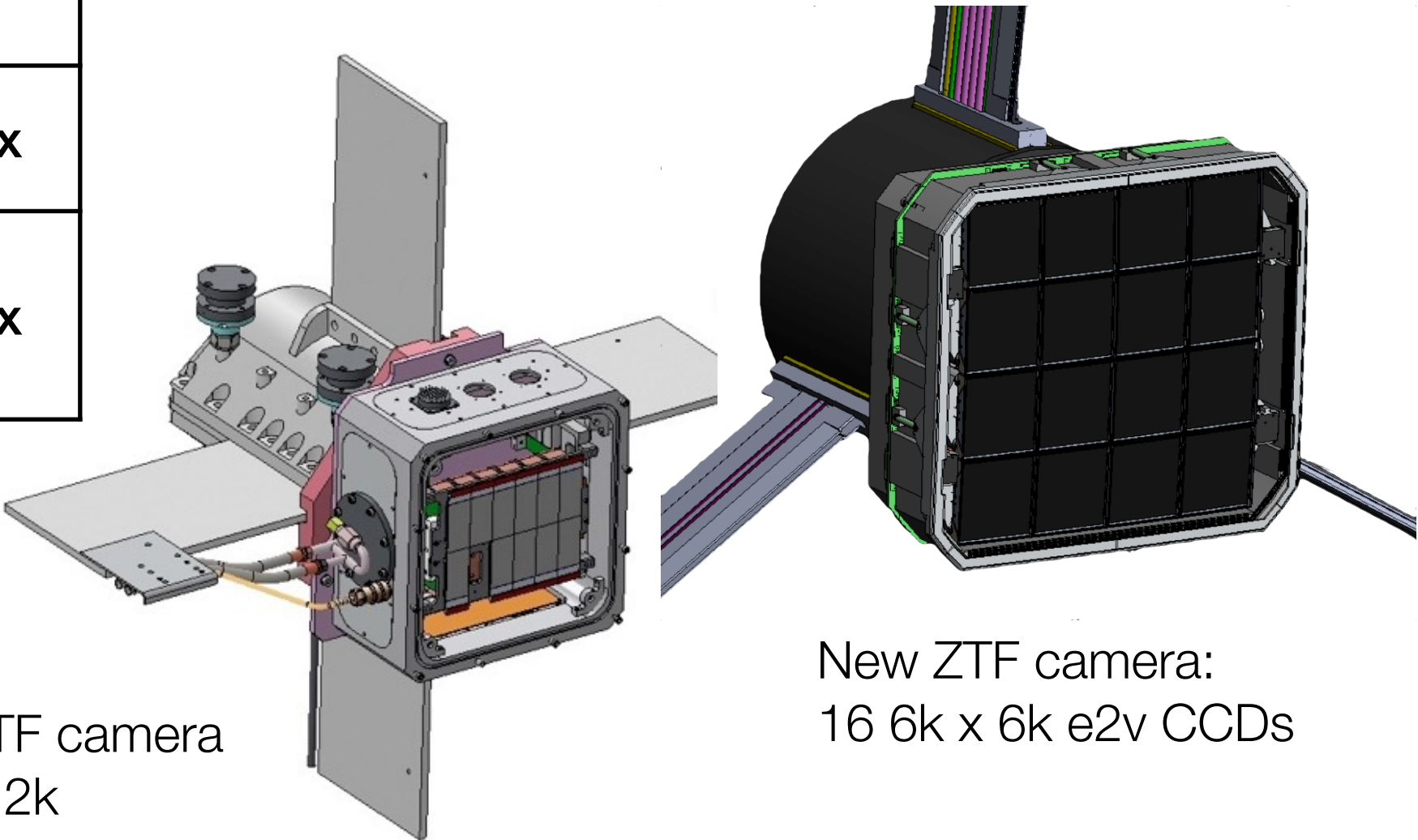
ZTF will survey an order of magnitude faster than PTF.

	PTF	ZTF
Active Area	7.26 deg ²	47 deg ²
Overhead Time	46 sec	<15 sec
Optimal Exposure Time	60 sec	30 sec
Relative Areal Survey Rate	1x	15.0x
Relative Volumetric Survey Rate	1x	12.3x

3750 deg²/hour

⇒ 3π survey in 8 hours

>250 observations/field/year
for uniform survey



Existing PTF camera
MOSAIC 12k

New ZTF camera:
16 6k x 6k e2v CCDs

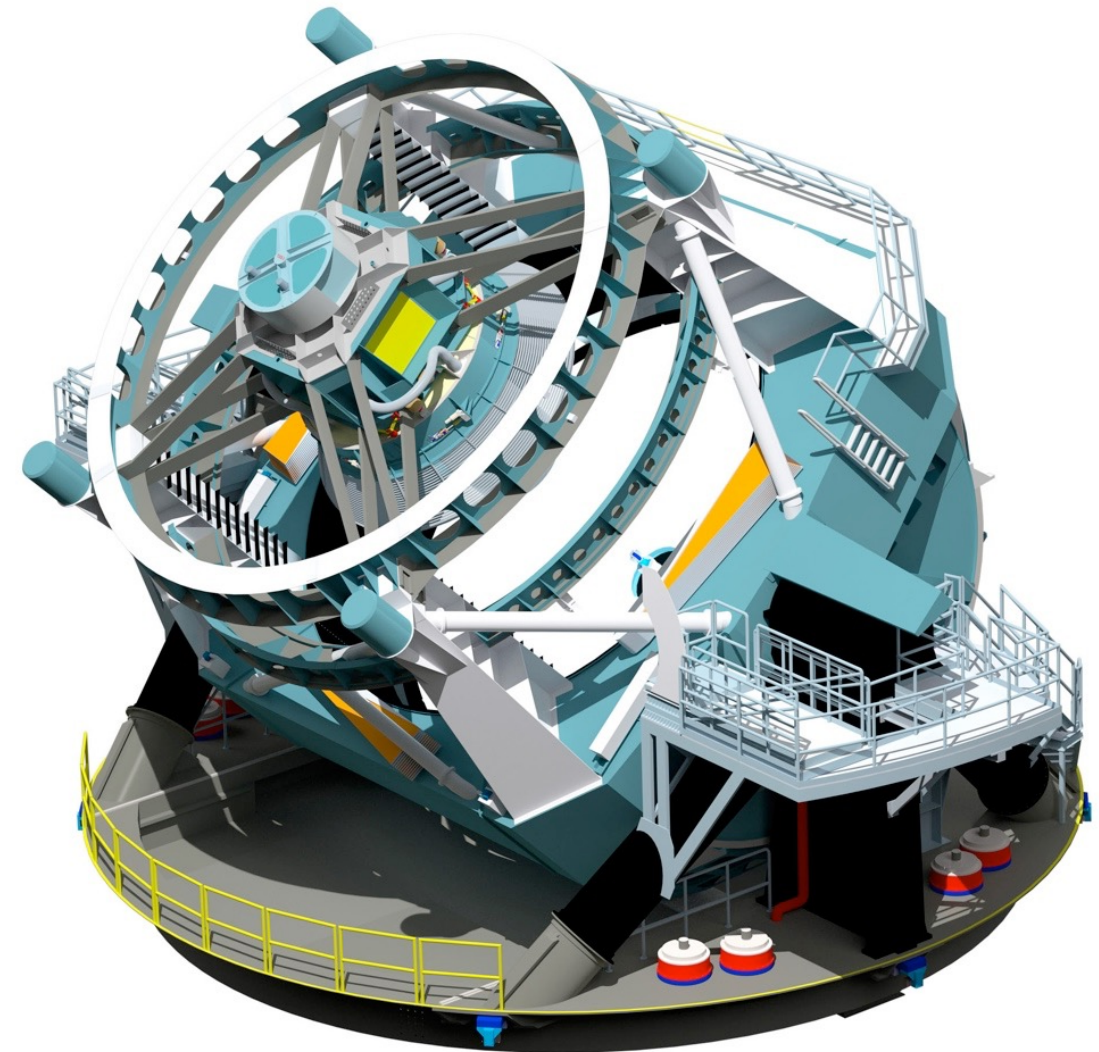
ZTF and LSST are quite different!

	ZTF	LSST
Aperture	1.2 m	6.7 m
Field of View	47 deg ²	9.6 deg ²
Median Image Quality	2.0"	0.7"
Filters	g, r	u, g, r, i, z, y
Single exposure magnitude range (r)	13.5-20.5	16-24.7
Areal survey speed	3760 deg ² hr ⁻¹	840 deg ² hr ⁻¹
Average yearly observations per field	290	64
Survey dates	2017-2020	2022-2032

ZTF provides a natural stepping stone to LSST.

PTF: 4×10^4 events/night
ZTF: 3×10^5 events/night
LSST: 2×10^6 events/night

Technical	develop algorithms & software for detection & classification
Scientific	discover new transient & variable phenomena
Organizational	organize collaborations and followup strategies with real data
Workforce	train the next generation of time-domain scientists!



ZTF will perform two general purpose surveys for the US community.

Northern Sky Survey

Analogous to LSST Wide-Fast-Deep

3-day average cadence on visible sky

systematic samples of AGN, supernovae, SLSNe, TDE, halo RR Lyr...

Galactic Plane Survey

300 visits/year ($\delta > -30^\circ$, $|b| < 7^\circ$; $\Delta l = 240^\circ$)

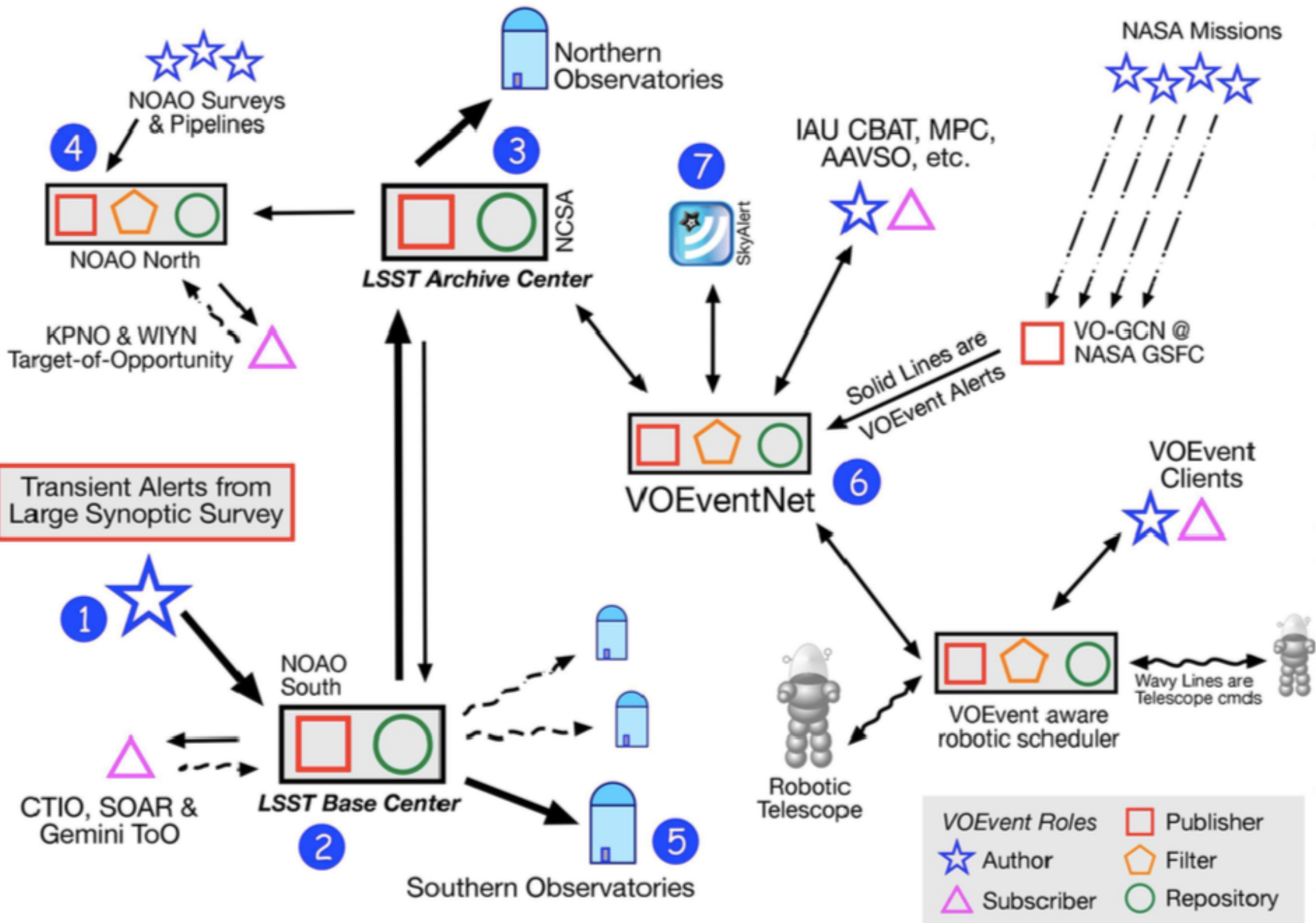
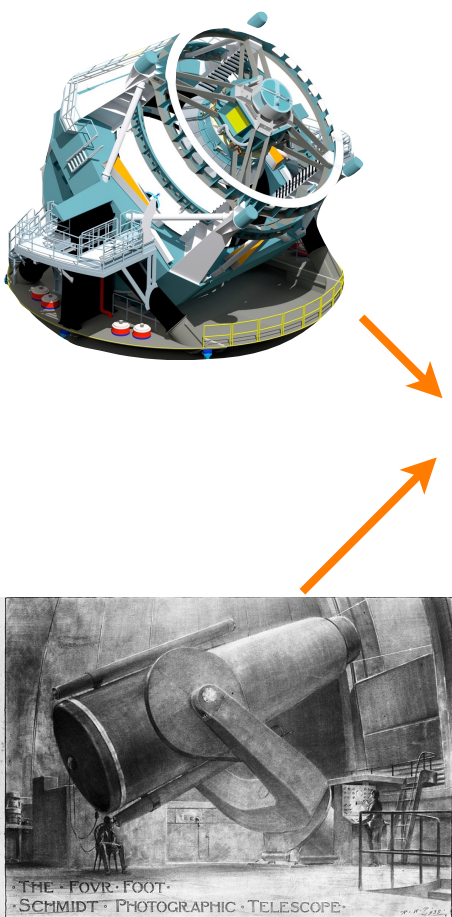
large-scale gyrochronology, young star outbursts, M-dwarf flares, rare and exotic variables and binaries...

combine to ~50% of the collaboration time

ZTF will provide a live alert stream to prototype event brokers and enable transient discovery.

LSST Transient Alerts VOEventNet Architecture

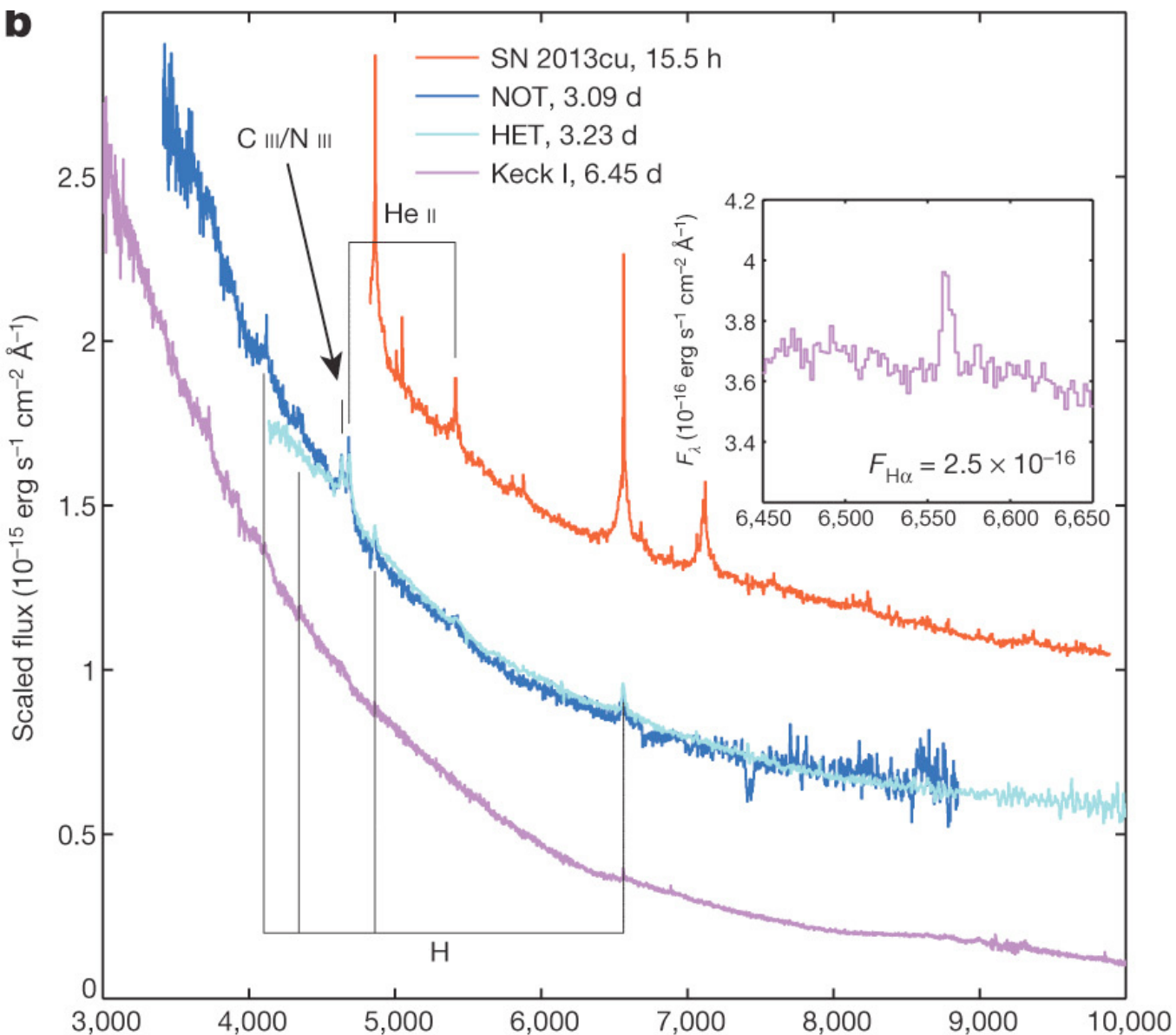
Smith+ 2010



Early observations of young SNe test progenitor physics.

iPTF13ast/SN2013cu (IIb)

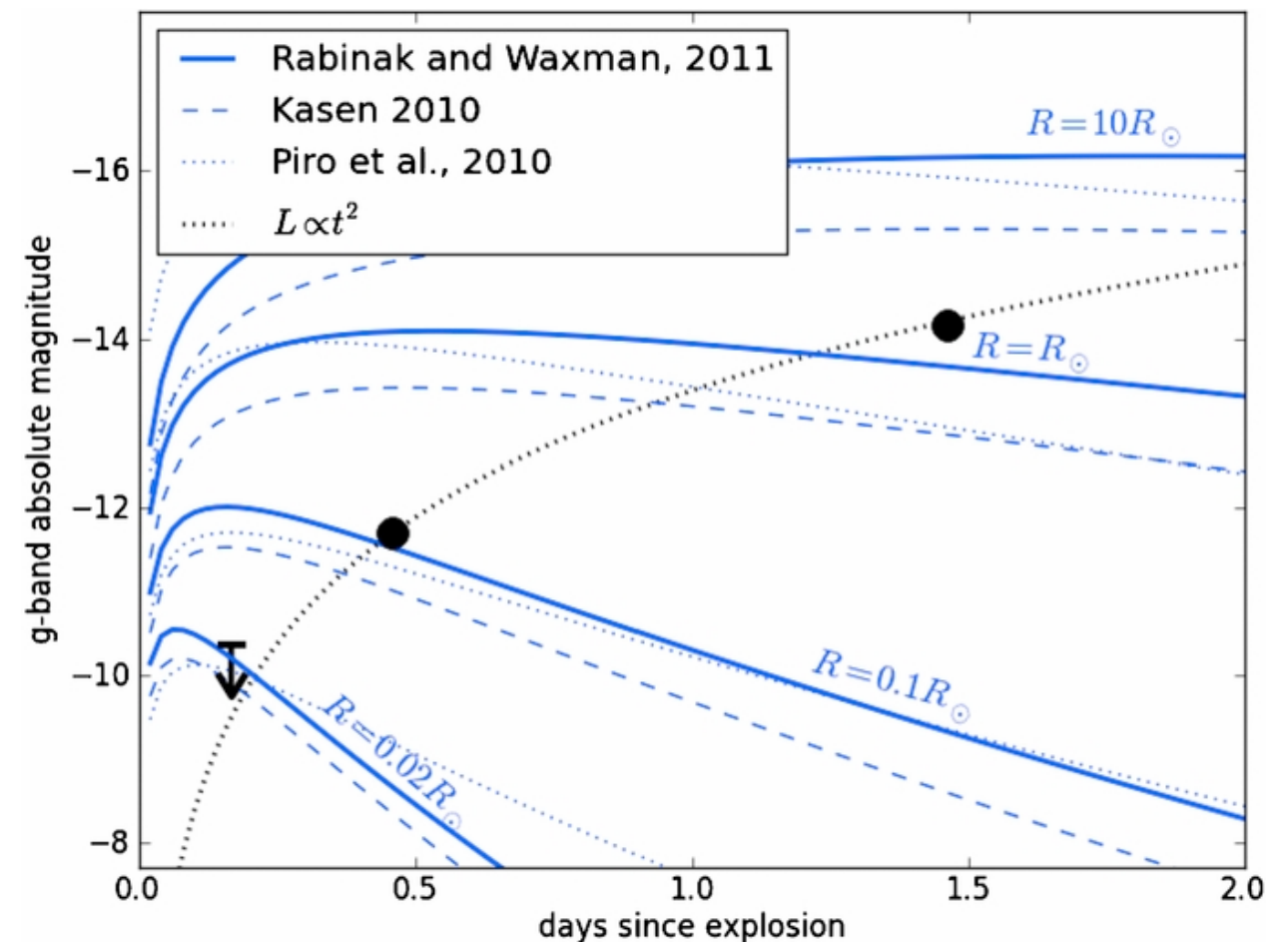
Gal-Yam+ 2014



“flash” spectroscopy finds
progenitor signatures in
ionized wind

PTF11kly/SN 2011fe (Ia)

Bloom+ 2012

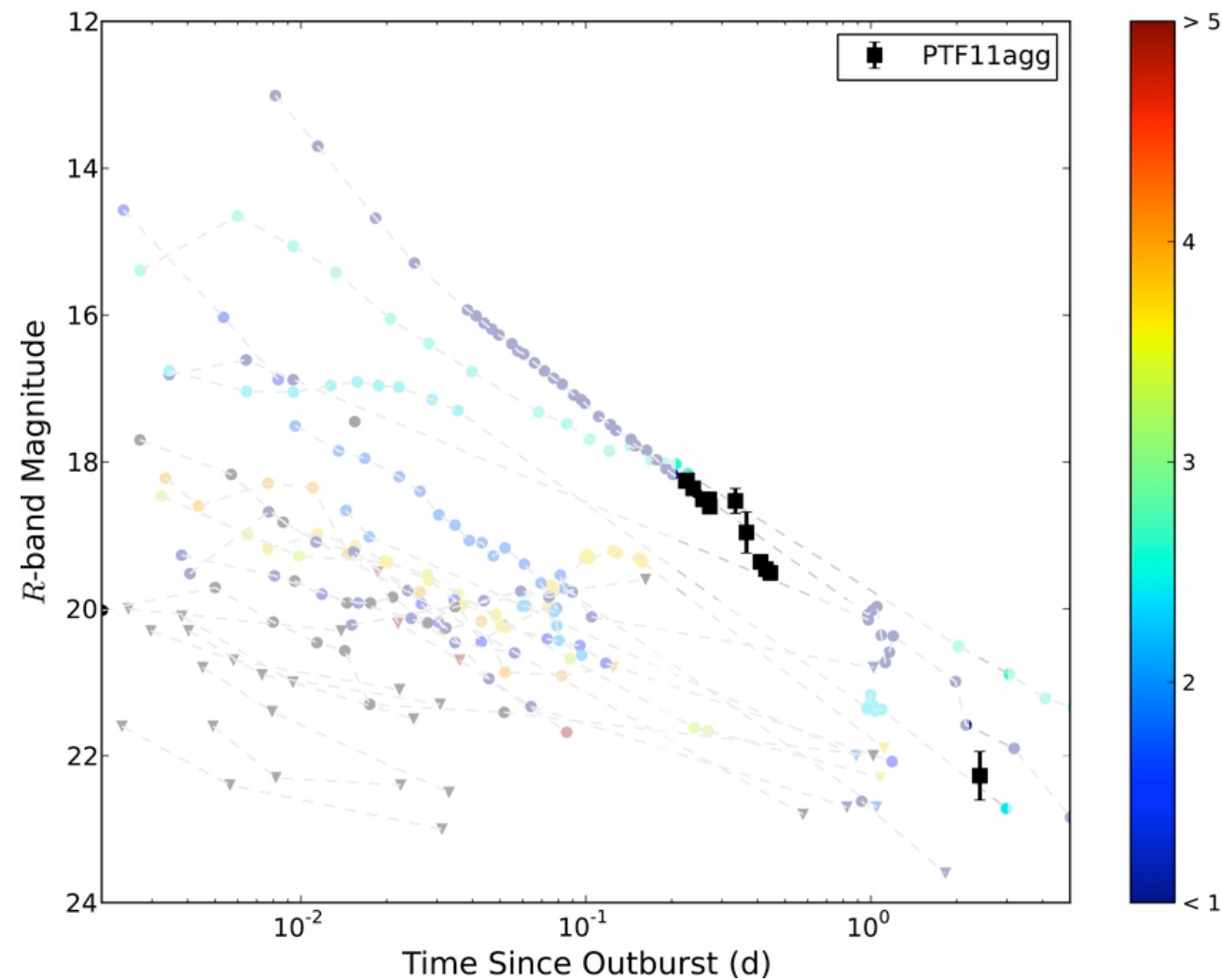


early photometry
constrains progenitor radius

**ZTF will discover a supernova
< 24 hours old *every night***

(Sub)relativistic explosions produce rare fast transients.

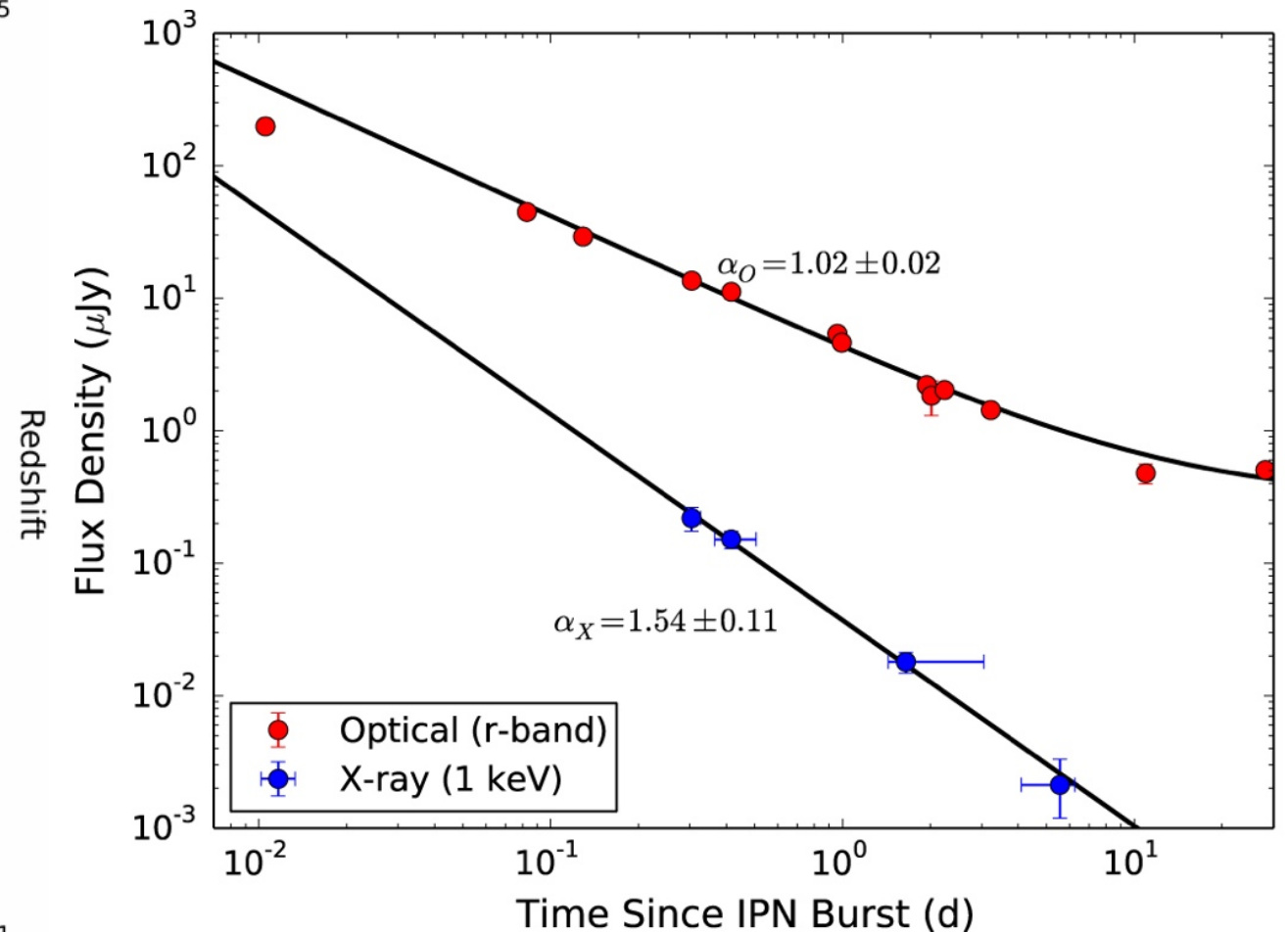
PTF11agg
Cenko+ 2013



untriggered GRB afterglow?

dirty fireball?

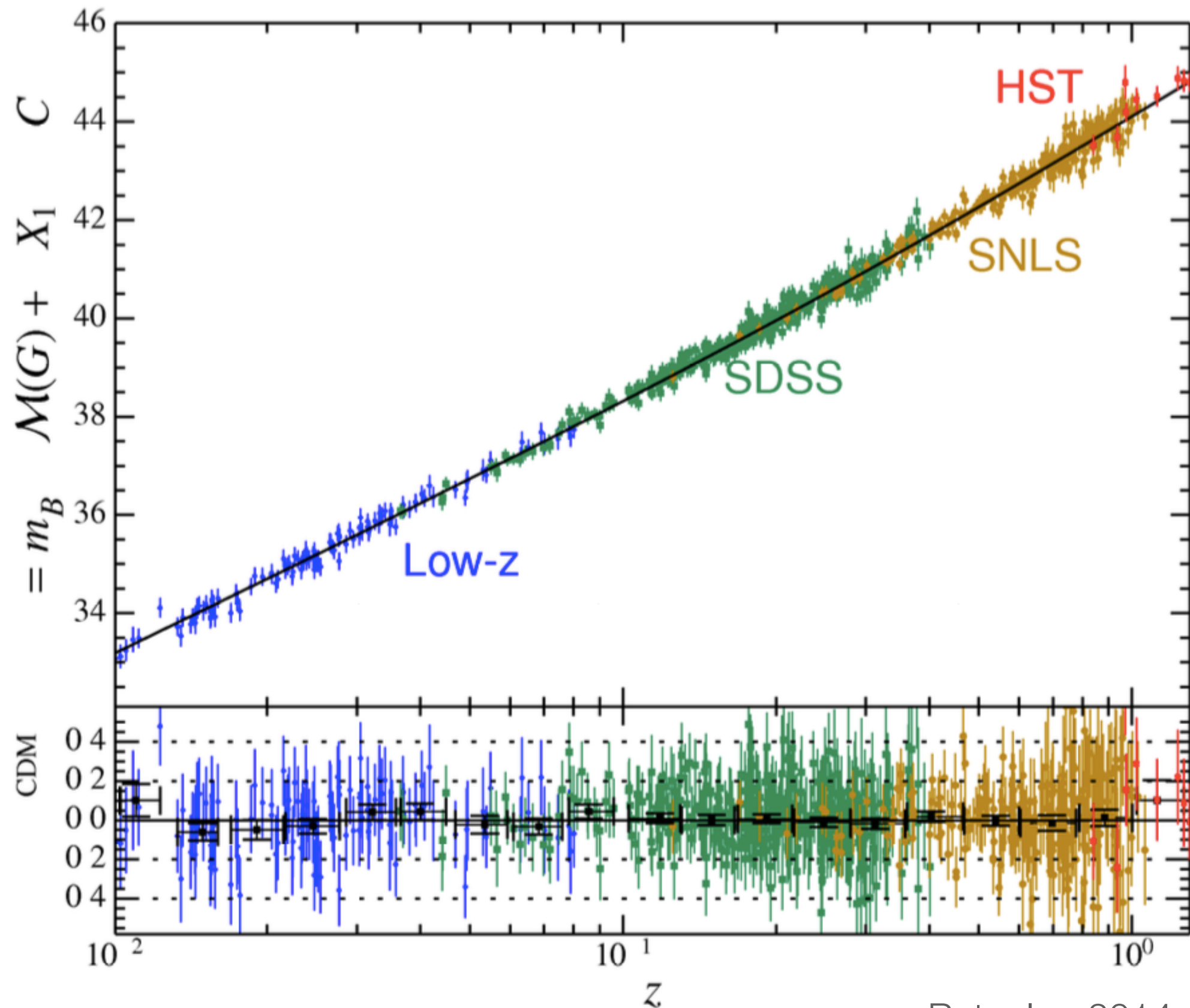
iPTF14yb
Cenko+ 15



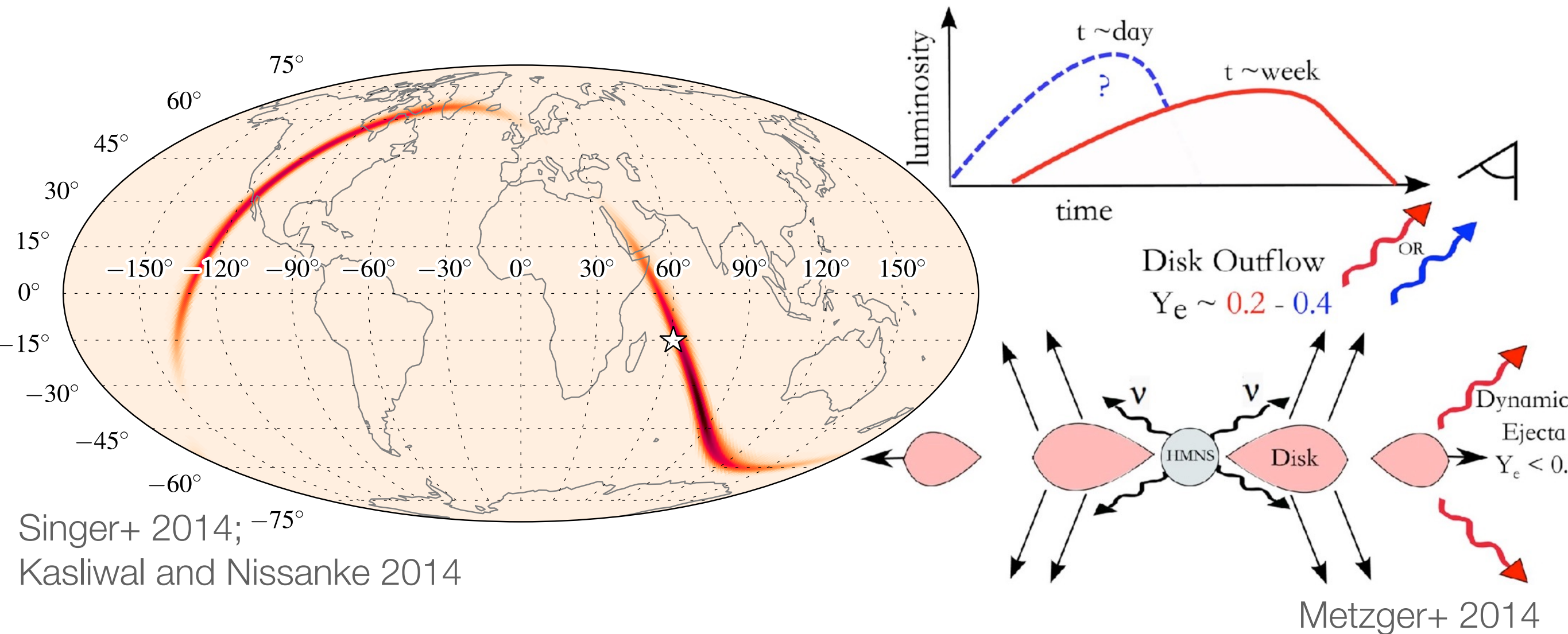
first optically discovered GRB

**ZTF will discover ~10
GRB afterglows and related
transients each year**

ZTF SNe Ia can anchor the Hubble diagram.



EM counterparts to GW sources will reveal key physics, but they will be challenging to localize.



requires:

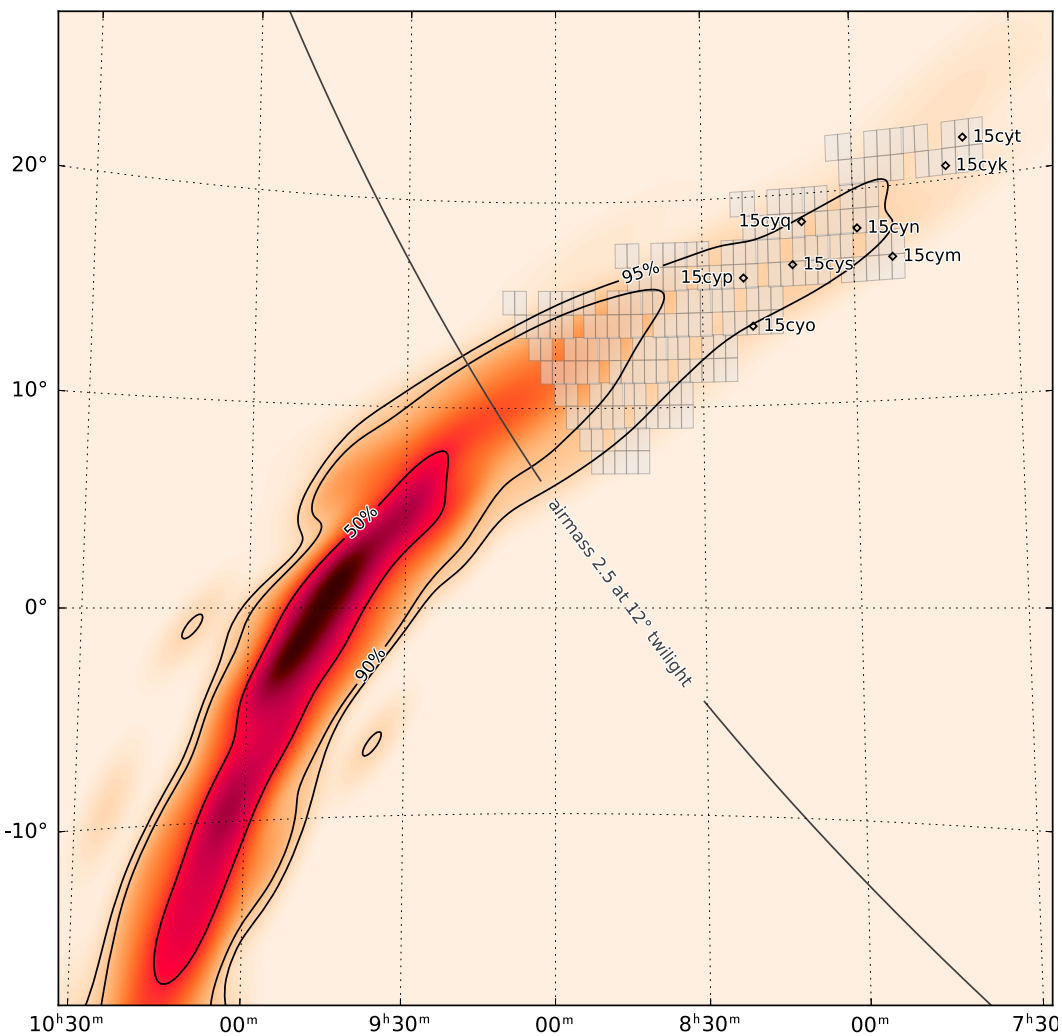
- fast survey speed
- fast & reliable image subtraction
- fast spectroscopic response

helpful to remove false positives:

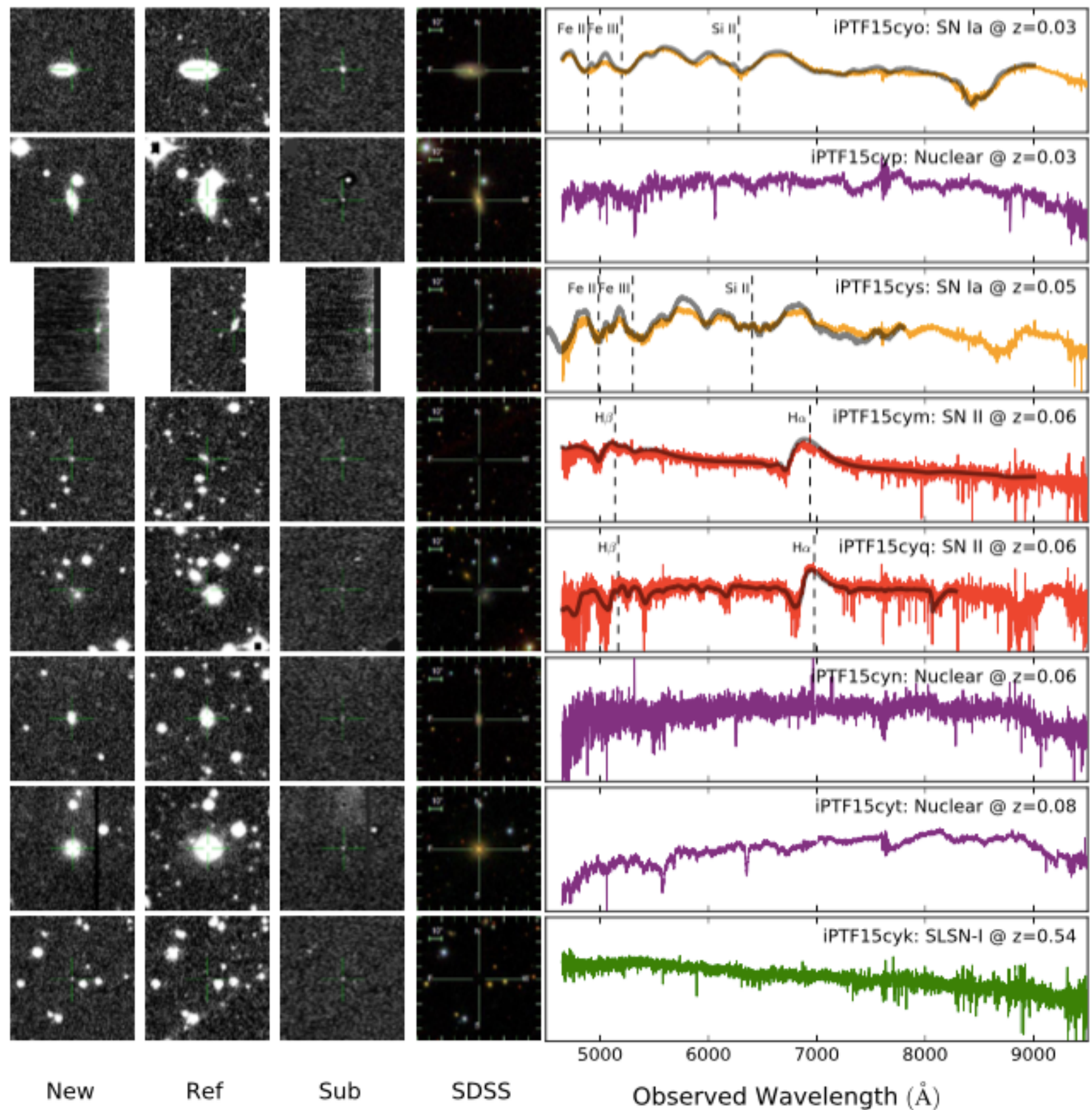
- deep all-sky coadds
- catalog of variable sources
- local galaxy catalog

ZTF is well-positioned to search for GW counterparts 23

iPTF is already following up Advanced LIGO triggers.

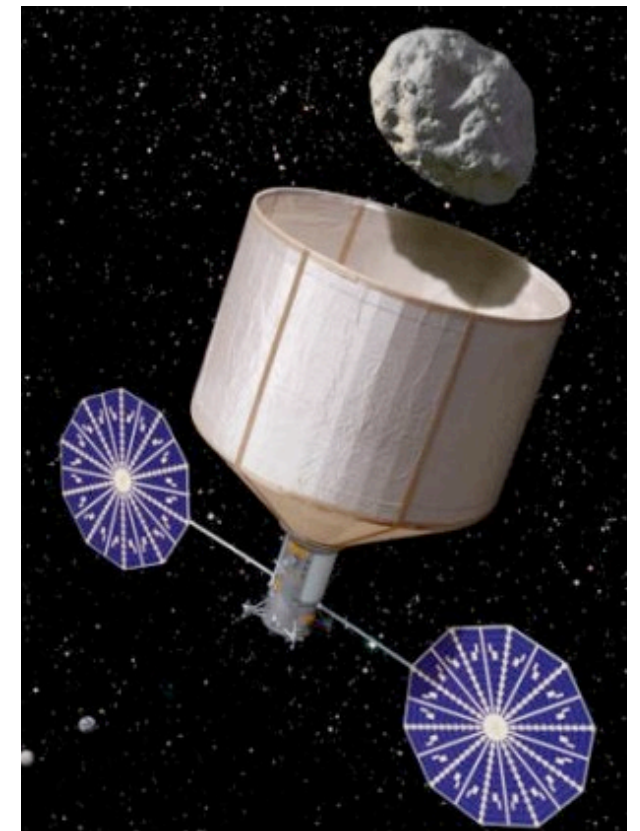
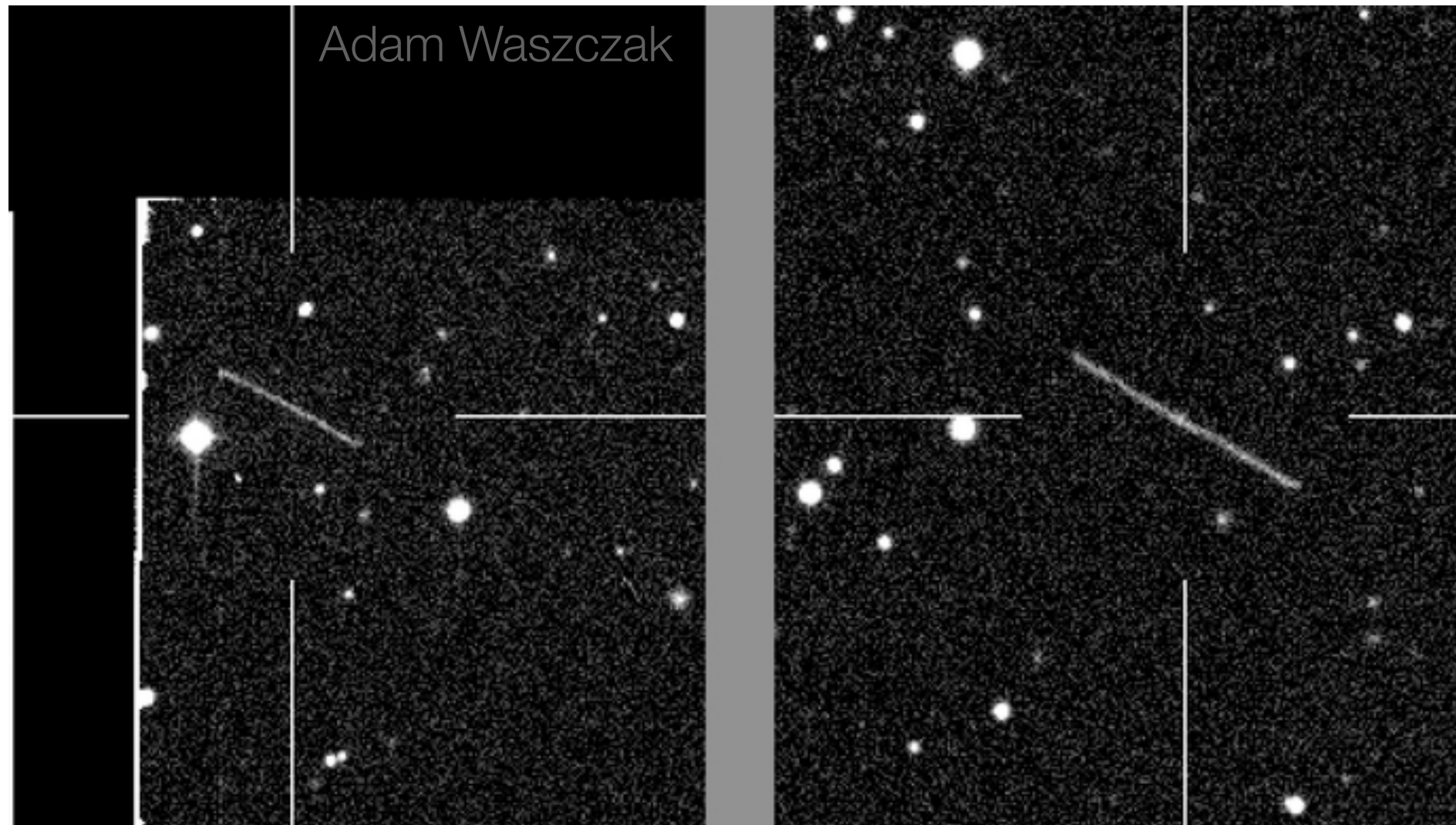


Kasliwal+ 2016



Near Earth Asteroids pose a threat and an opportunity.

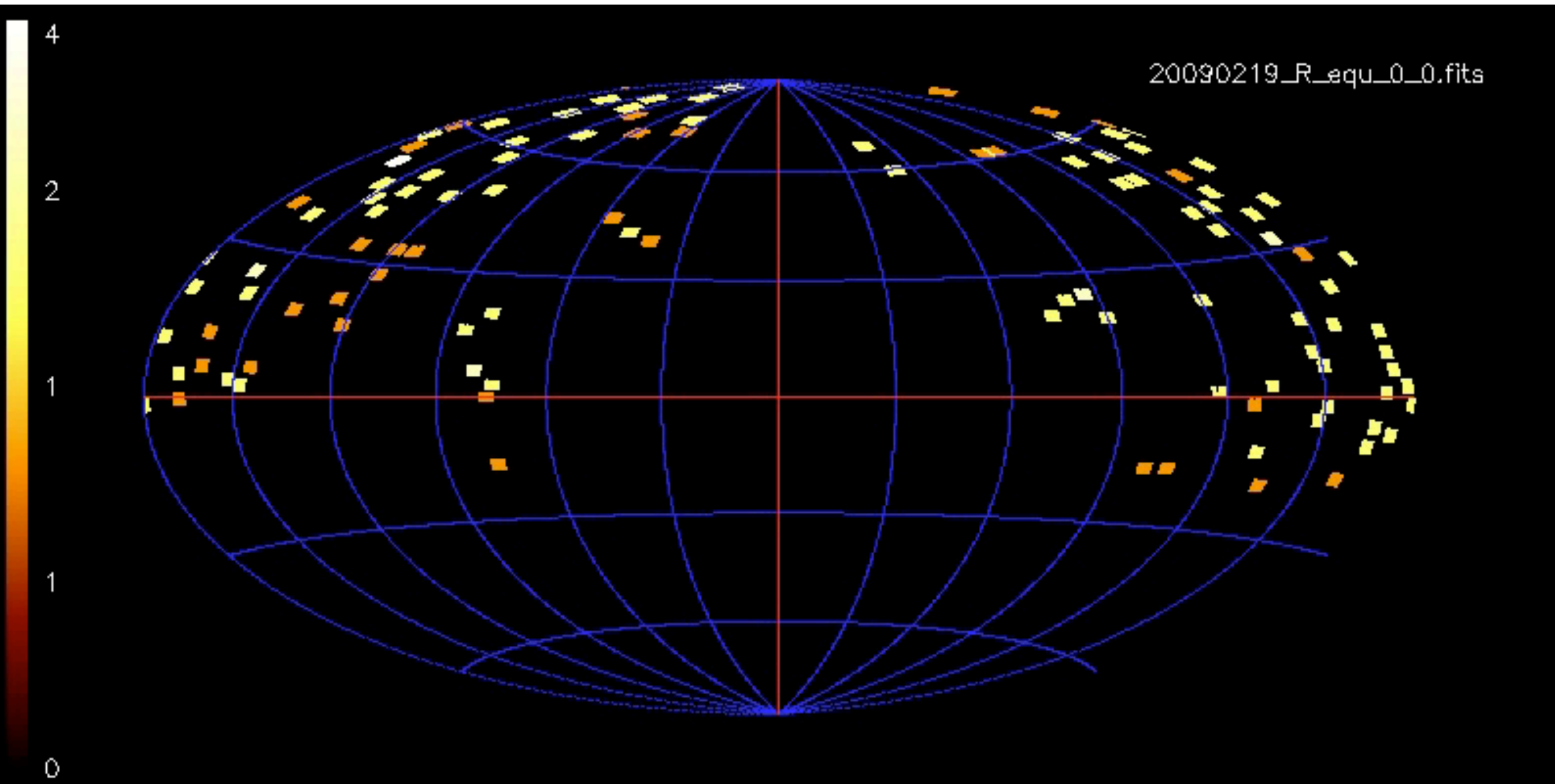
iPTF-discovered NEA 2014 JG55



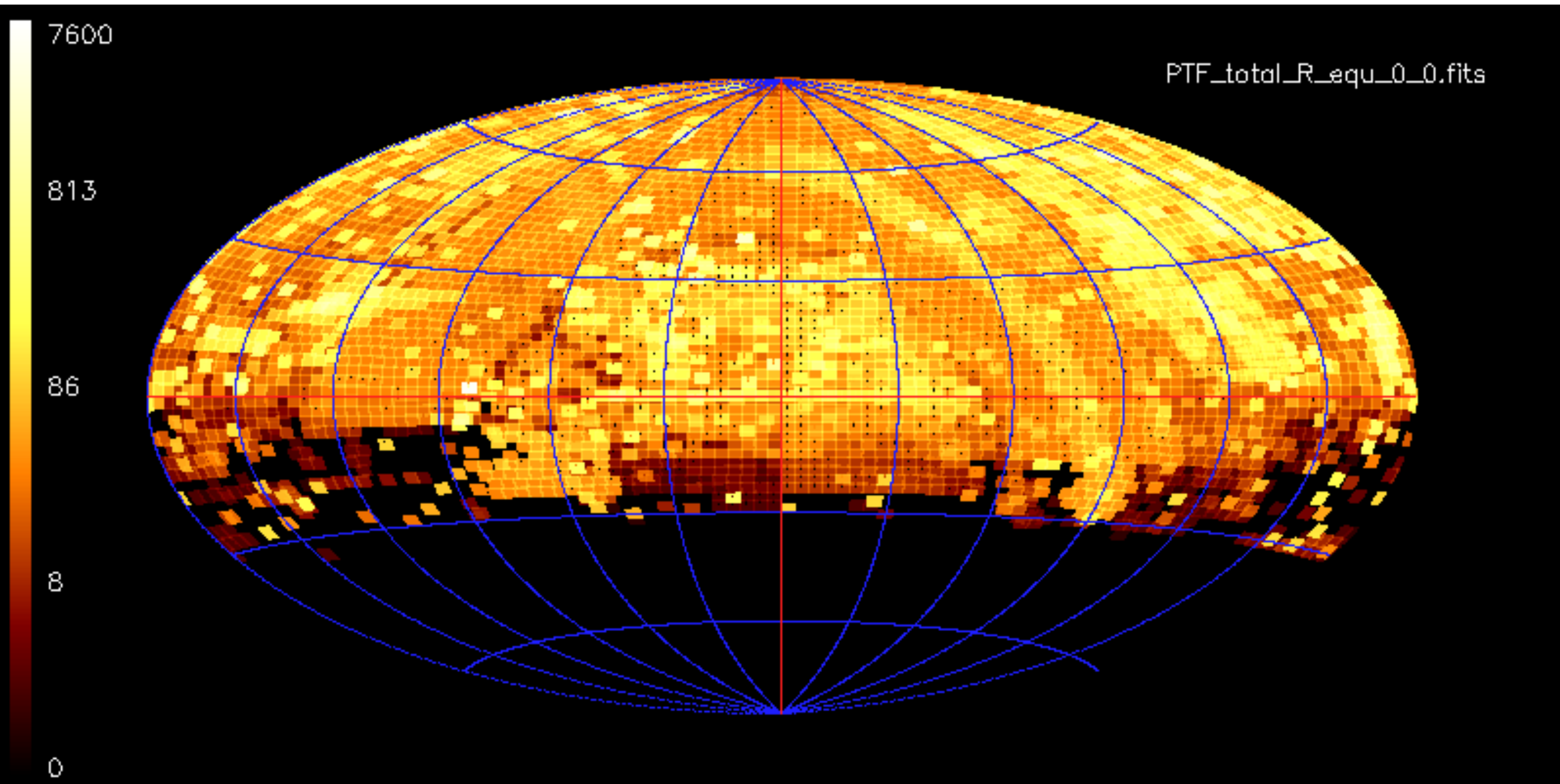
Passed 1/4 of a lunar distance from Earth!

**ZTF can perform a
sensitive search for streaking NEAs.**

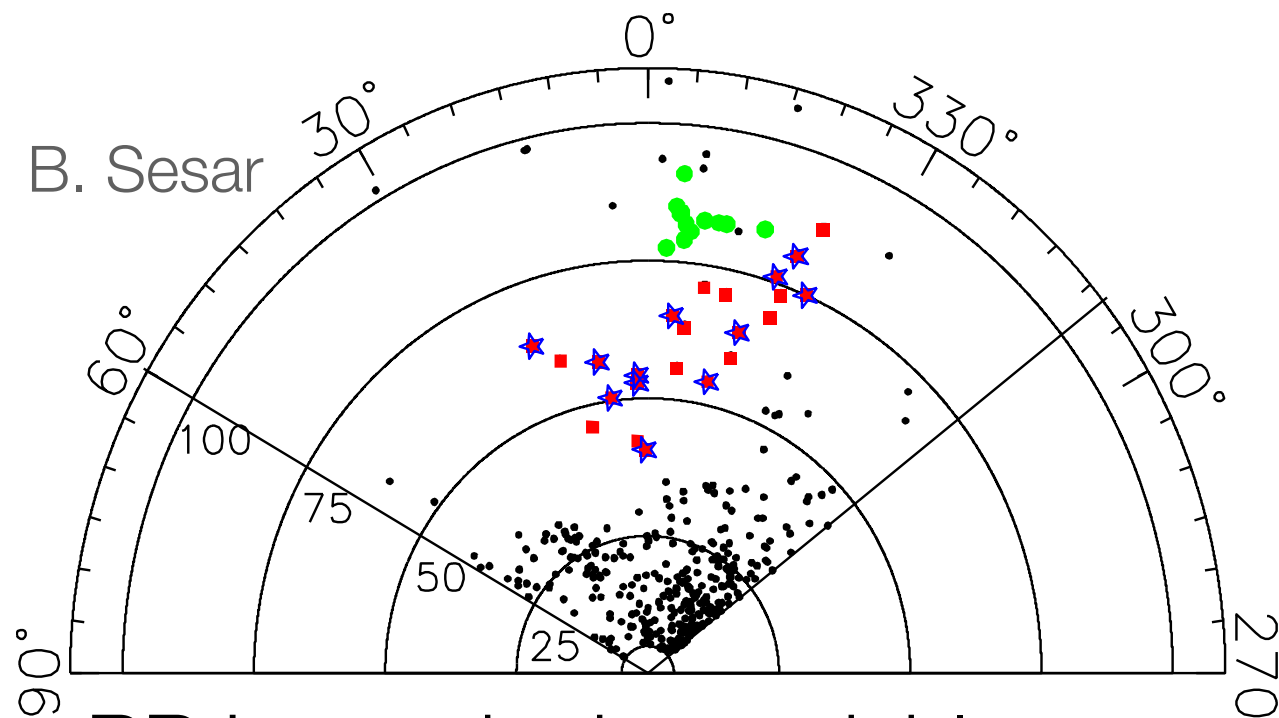
Long-running transient surveys are great for variability!



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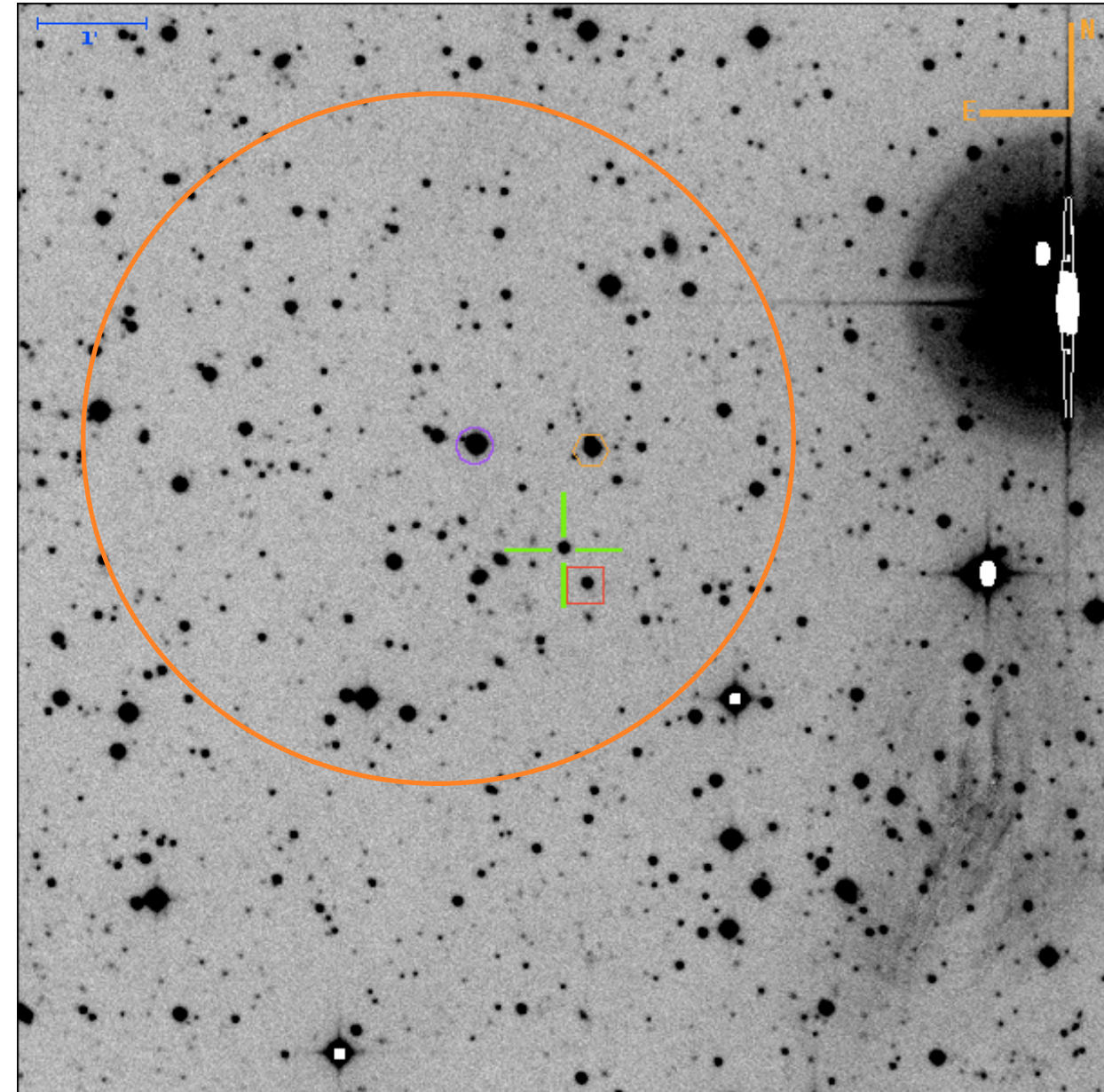
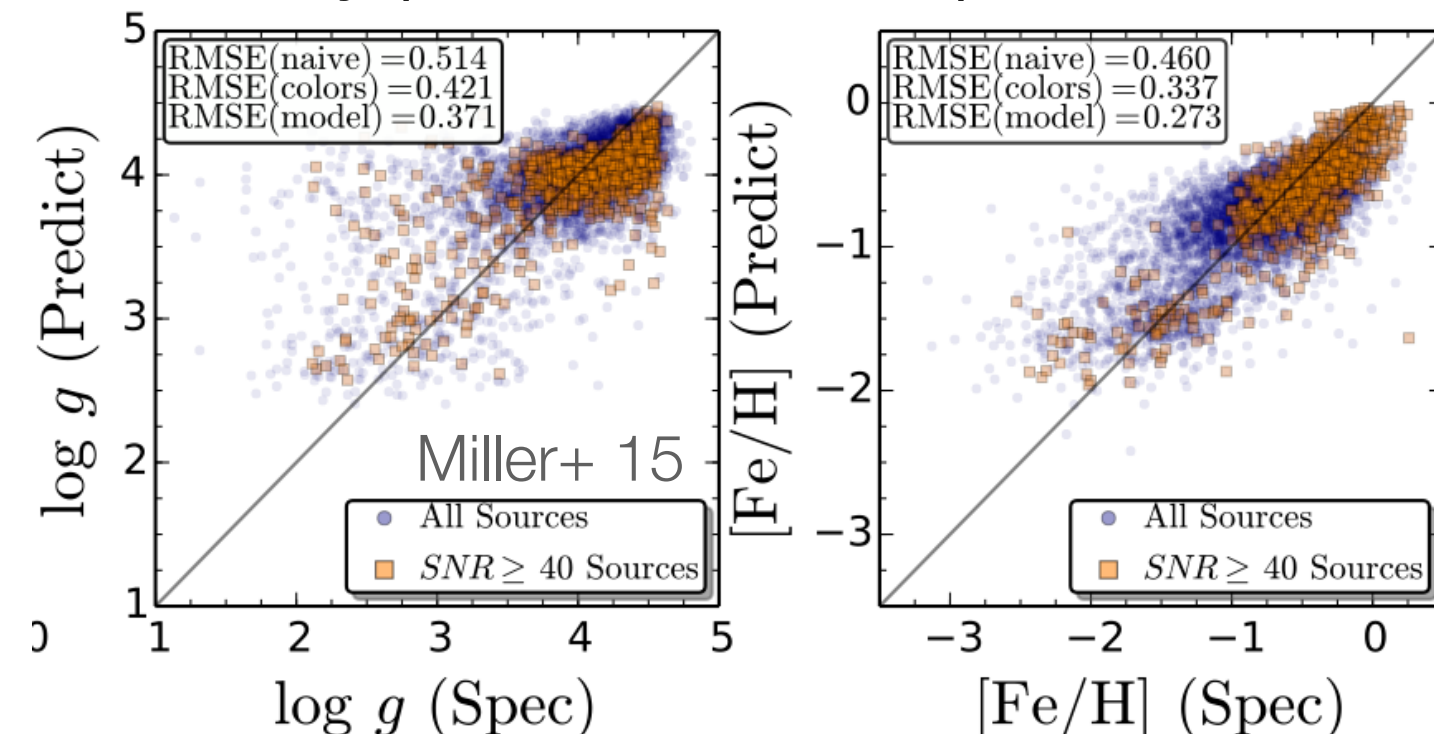


ZTF's variability catalogs will enable great science.



RR Lyr and other variables trace Galactic Structure

variability predicts stellar parameters

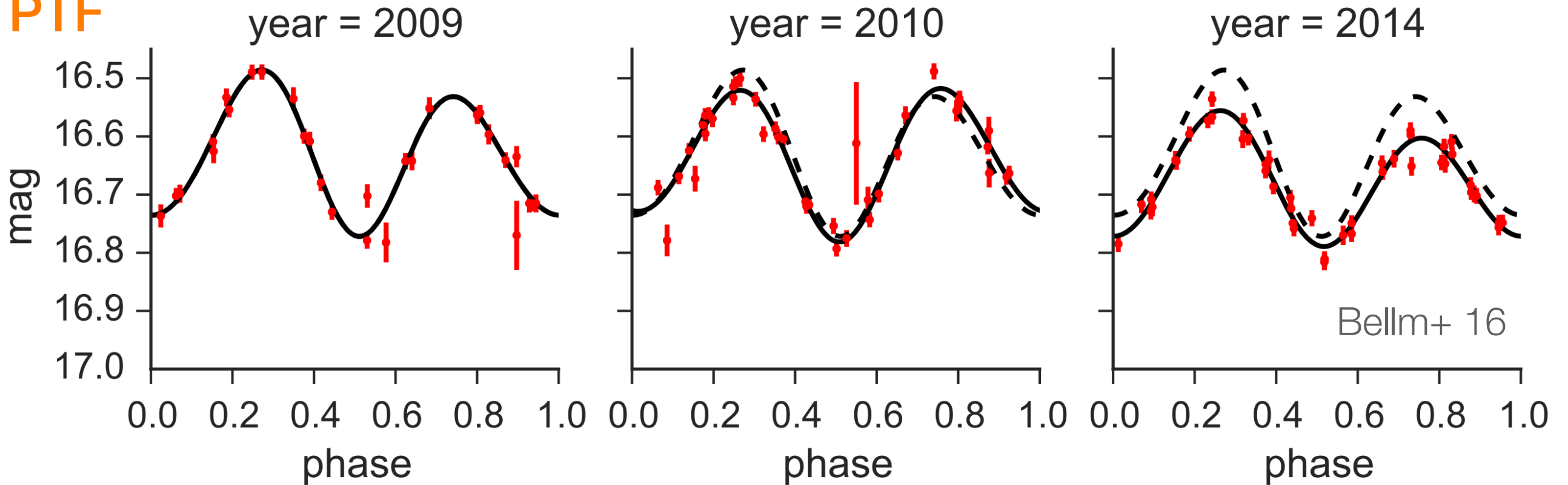


find high-energy counterparts

ZTF will obtain an average of more than 250 epochs each year over the Northern Sky

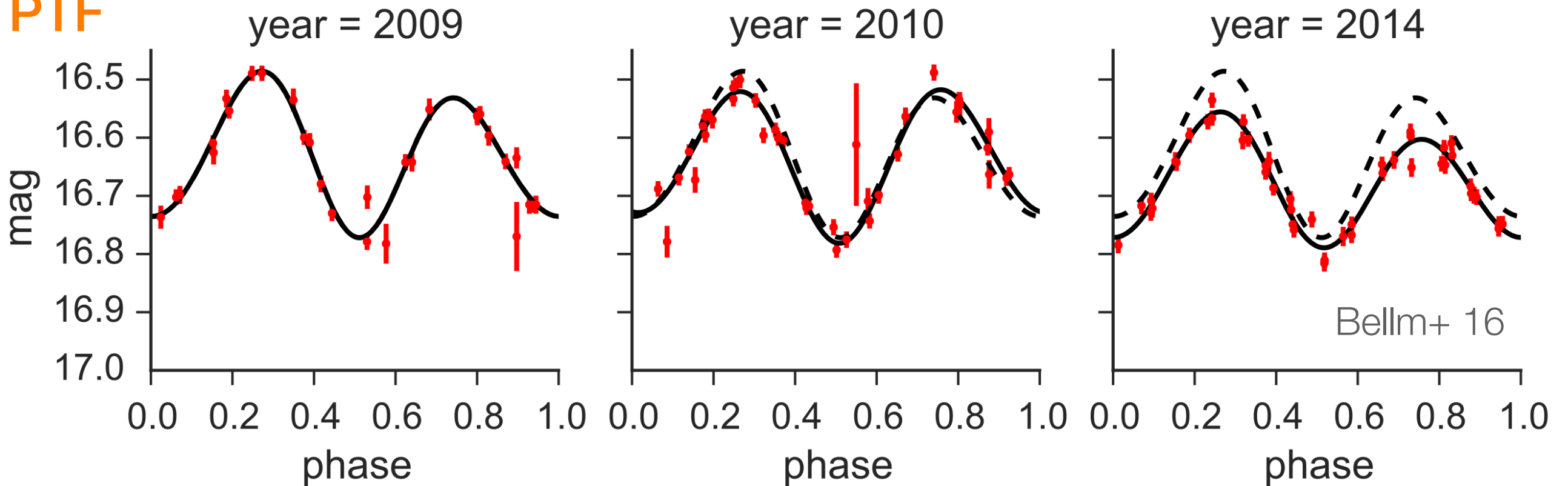
ZTF's variability catalogs will enable great science.

PTF

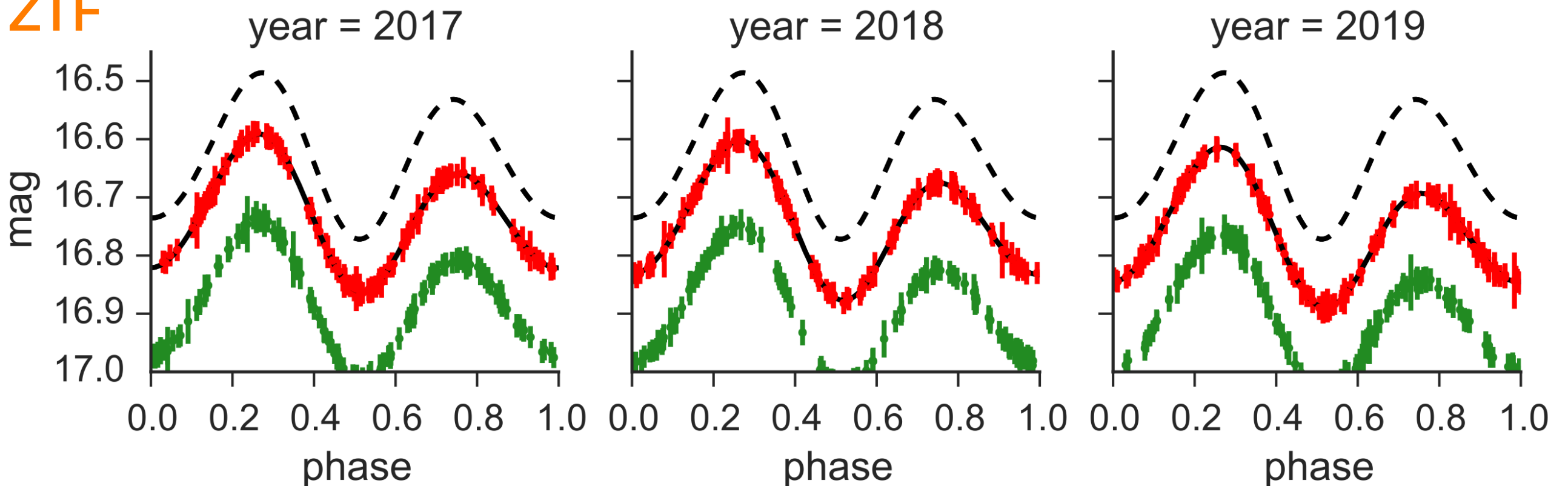


ZTF's variability catalogs will enable great science.

PTF



ZTF



ZTF's variability catalog can bootstrap LSST science.

Cross-correlate ZTF variability (+PS1?) with your favorite catalog!
X-ray catalogs...

Identify bright variables in the spatial overlap region
(Dec > -30, $16 < m < 21$ mag)
Clear the “foreground fog” in the first LSST years

Train Machine Learning classifiers on spectroscopically-confirmed samples.
e.g., proposal for After Sloan IV “Stellar Binary Survey”

Yearly ZTF summer schools introduce young researchers to time-domain methods.



July 17-20, 2016 <http://www.ptf.caltech.edu/page/meetings>

MSIP funding provides access to PTF, iPTF, & ZTF data.

2015: Complete PTF archive released

see http://www.ptf.caltech.edu/page/data_access

September 2016: Initial release of iPTF data, including lightcurves

2017: ZTF first light, commissioning, and reference building

2018: First ZTF data release; public transient alerts begin

2019: Public alerts of transient candidates & cutouts begin

2020: End of MSIP-funded survey; final data releases

ZTF is coming in 2017!

Wide & high cadence survey will enable new science
and provide a stepping stone to LSST
Public data and summer schools are already available

